Water Quality Restoration Plan
Upper Klamath Basin

February 2003

USDA Forest Service
Winema and Fremont National Forests
USDI Bureau of Land Management
Lakeview District, Klamath Falls Resource Area

This Water Quality Restoration Plan for the Upper Klamath Basin has been prepared to fulfill a requirement of Section 303(d) of the Clean Water Act. It is organized according to the direction contained in *Guidance for Developing Water Quality Management Plans That Will Function as TMDLs for Nonpoint Sources, November 1, 1997,* Oregon Department of Environmental Quality Water Quality Division, and *Forest Service and Bureau of Land Management Protocol for Addressing Clean Water Act Section 303(d) Listed waters, May 1999*.

The US Forest Service administers most of the federal land in the area covered by this WQRP. Because the BLM manages a much smaller land area, it was decided early in the TMDL process that the FS would serve as the lead for addressing issues relevant to BLM land.

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This Water Quality Restoration Plan is on file and are available for public review at: http://www.fs.fed.us/r6/winema/management/tmdl/index.shtml and at the following offices:

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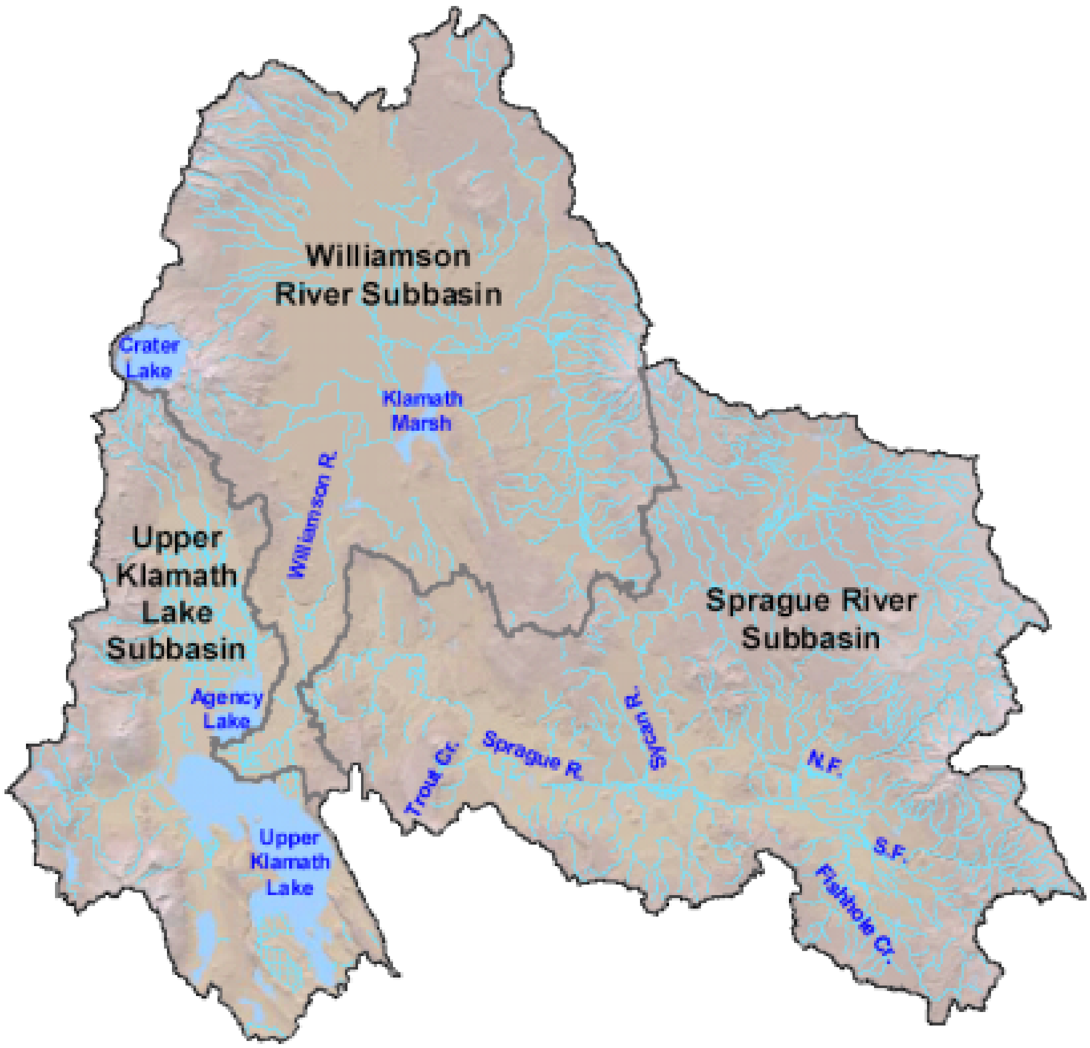

Figure 1. Upper Klamath River Basin (Source ODEQ 2002).

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Upper Klamath River Basin Water Quality Restoration Plan

1. Background and Overview

1.1 What is a Water Quality Restoration Plan?

It is the obligation of the United States Forest Service (FS) and the Bureau of Land Management (BLM) to restore water quality limited water bodies under their management to conditions that meet or exceed standards for the protection of designated beneficial uses, and to maintain waters that meet or exceed water quality standards. Water Quality Restoration Plans provide a plan that agencies will use for applying the necessary strategies and actions which will be used to restore water quality impaired waters (ICBEMP, 1998). The purpose of this Water Quality Restoration Plan (WQRP) is to provide information on management measures the FS and BLM are taking to reduce non-point sources of pollution for surface waters on federal lands within the Upper Klamath Basin. Water Quality Restoration Plans are typically completed as a component of Total Maximum Daily Loads (TMDLs) allocations, which are explained in the next section.

The FS and the BLM are the Designated Management Agencies (DMA's) responsible for implementing water quality protection efforts on lands they manage in the Upper Klamath Basin. The actions and policies summarized in this plan are part of on-going FS and BLM commitments, in cooperation with the Oregon Department of Environmental Quality (ODEQ, 2002b), to comply with the goals of the Federal Clean Water Act (CWA) for water quality improvement and management.

For the purposes of this plan, the Upper Klamath Basin (UKB) comprises those areas that drain into Upper Klamath Lake. Fourth field hydrologic units in the Upper Klamath Basin include the Sprague River sub-basin, the Williamson River sub-basin, and the Upper Klamath Lake sub-basin. Numerous streams in these drainages do not meet water quality standards. The management described in this WQMP will apply to water bodies within the Upper Klamath River basin above Upper Klamath Lake on over 1.2 million acres of federal lands managed by the Winema and Fremont National Forests, and seven thousand acres of land managed by the BLM Klamath Falls Resource Area.

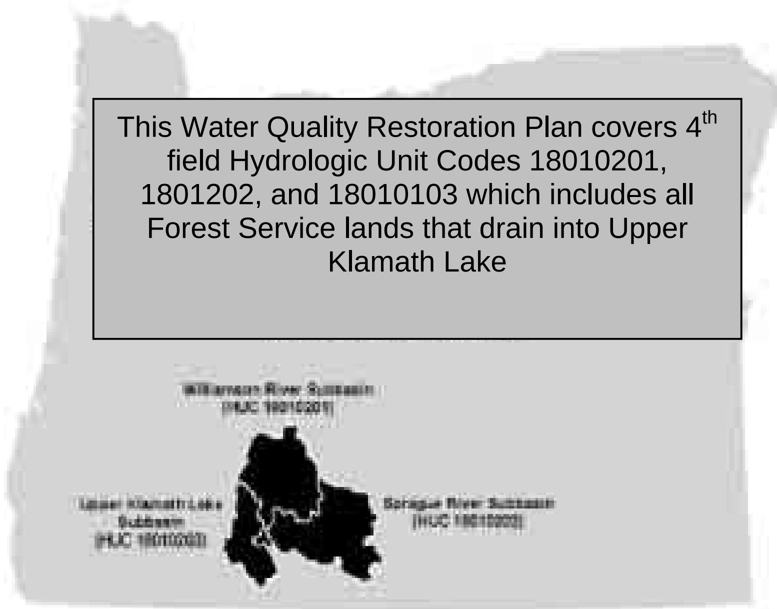

Figure 2. Location of Upper Klamath Basin in State of Oregon.

1.1.1 What is a TMDL?

The term "water quality limited" is applied to streams and lakes where violations of State water quality standards occur. Section 303(d) of the 1972 Federal Clean Water Act requires that water bodies that violate water quality standards, and thereby fail to fully protect beneficial uses, be identified and placed on a 303(d) list. The Upper Klamath Lake drainage has 20 streams on the 1998 303(d) list for exceeding temperature standards. All segments were listed based upon exceedences of the 64^{o} F stream temperature criteria. With a few exceptions, such as in cases where violations are due to natural causes, the Oregon Department of Environmental Quality (ODEQ) must establish a Total Maximum Daily Load or TMDL for any waterbody designated as water quality limited. A TMDL is formulated to account for the total amount of a pollutant (from all sources) that can enter a specific waterbody without violating the water quality standards. The loading capacity is the total permissible pollutant load that is allocated to point, non-point, background, and future sources of pollution. Load allocations are portions of the loading capacity that are attributed to either natural background sources, such as from soil erosion, or from non-point sources, such as urban, agriculture or forestry activities. Load allocations are developed from mathematical models and other analytical techniques and include a "margin of safety" that characterizes the level of uncertainty in the allocation. Models and analytical techniques are simplifications of complex physical, biological, and chemical processes, and the margin of safety was established to account for such factors as the amount of data that is available, and how well these processes are understood.

Goals for water quality improvement in the Upper Klamath Basin have been established in the Upper Klamath Lake Drainage Total Maximum Daily Load Allocation (ODEQ, 2002). The quality of the Upper Klamath Basin's streams and lakes is monitored by the FS and BLM in cooperation with ODEQ, the US Fish and Wildlife Service, and the US Bureau of Reclamation . This information is used to determine whether water quality standards are being met and, consequently, whether the beneficial uses of the waters are being maintained or impaired. Designated beneficial uses for the Upper Klamath Basin include fisheries, aquatic life, drinking water, recreation and irrigation. Specific State and Federal plans and regulations are used to determine if violations have occurred: these regulations include the Federal Clean Water Act of 1972 and its amendments 40 Code of Federal Regulations 131, and Oregon's Administrative Rules (OAR Chapter 340) and Oregon's Revised Statutes (ORS Chapter 468).

1.1.2 TMDL Implementation and Water Quality Management Plans

Development and implementation of TMDLs is critical to the attainment of water quality standards. The support of DMA's in implementing TMDLs is essential. A DMA is any agency or entity responsible for affecting water quality through its management of land and/or water. In instances where DEQ has no management authority for TMDL implementation, DEQ works with DMA's on implementation to ensure attainment of water quality standards. The DMAs in the Upper Klamath Lake drainage include: FS, BLM, US Bureau of Reclamation, US Fish and Wildlife Service, Crater Lake National Park, Oregon Department of Agriculture, Oregon Department of Forestry, Klamath County, and the City of Klamath Falls. These agencies have developed water quality management plans (WQMP) to address load allocations identified in the 1988 TMDLs. Both the TMDLs and their associated WQMP will be submitted by DEQ to EPA as updates to the State's Water Quality Management Plan pursuant to 40 CFR 130.6.

1.2 Elements of a Water Quality Restoration Plan

This Water Quality Restoration Plan (WQRP) will address the ten basic elements provided in the ODEQ <u>Guidance For Developing Water Quality Management Plans That Will Function As TDMLs For Non-point Sources</u>, 1997. These elements include:

1. Condition assessment and problem description
2. Goals and objectives
3. Proposed management measures
4. Timeline for implementation
5. Identification of responsible participants
6. Reasonable assurance of implementation
7. Monitoring and evaluation
8. Public involvement
9. Maintenance of effort over time
10. Discussion of costs and funding

Previously developed plans have been completed that provide guidance for water quality protection. These plans apply to specific areas within the Upper Klamath Basin. Previously developed plans that are to be incorporated into this WQRP are:

- Record of Decision for Amendments to Forest Service and Bureau of Land Management Planning Documents within the Range of the Northern Spotted Owl (ROD) (USDA/USDI 1994), commonly known as the Northwest Forest Plan applies to both FS and BLM lands.

- Inland Native Fish Strategy, interim strategies for managing federally managed fish producing watersheds in eastern Oregon and Washington, Idaho, Western Montana, and portions of Nevada, USDA Forest Service, 1995.

- The Fremont National Forest Land and Resource Management Plan (LRMP 1989, as amended) applies to lands managed by the Fremont National Forest.

- The Winema National Forest Land and Resource Management Plan (LRMP 1990, as amended) applies to lands managed by the Winema National Forest.

- The Klamath Falls BLM Resource Area Resource Management Plan (1995) applies to BLM lands

- The Upper Klamath Basin and Wood River Wetland Resource Management Plan/ Environmental Impact Statement (1995) applies to BLM managed wetlands surrounding Upper Klamath Lake.

- Recovery plans available for listed fish (bull trout, suckers)

- U.S. Fish and Wildlife Service Biological Opinions

- Any other grazing plans

- Wild and Scenic Rivers Act

- Wilderness Management Plans

- The science used to develop the Interior Columbia Basin Ecosystem Management Project (ICBEMP) was utilized while preparing this document.

2.0 Condition Assessment and Problem Description

2.1 Land Use and Ownership

The Upper Klamath Basin (UKB) comprises approximately 2,400,000 acres in south-central Oregon. The Upper Klamath Lake, Sprague River, and Williamson River subbasins are home to productive forested and agriculture lands and have extensive waterbodies including very large marshes with abundant waterfowl, blue-ribbon trout streams, and large ranches. Most of the land (53.4%) within the UKB is managed by the Winema and Fremont National Forests, while the BLM manages less than 1% of the UKB. Other major ownership includes Crater Lake National Park (3%), U.S. Fish and Wildlife Service (1%), USBR (approx 1%), and the State of Oregon (<1%). The remainder is in private ownership that is either corporate timberland or in smaller individual holdings. Spatial distributions of land ownership are displayed in Figure 3.

Lands in the Upper Klamath Lake drainage are predominantly forested (69%) and shrubland/grassland (14%). Agriculture (farming and grazing) occur in 5% of the Upper Basin. Wetlands and water make up 6% and 3.7% of the surface area, respectively.

Table 1. Land ownership in the Upper Klamath River Basin.

OWNERSHIP	AREA (ACRES)	OWNERSHIP (%)
Winema and Fremont N.F's.	1,284,336	53.4
Private or unknown	954,423	42.3
Crater Lake N.P.	77,347	3
U.S. Fish/Wildlife	13,185	1
State of Oregon	64,953	<1
Bureau of Land Mgt.	7,189	<1
Rogue River N.F.	1,078	<1
Deschutes N.F.	705	<1
Total acres in Upper Basin	**2,396,475**	

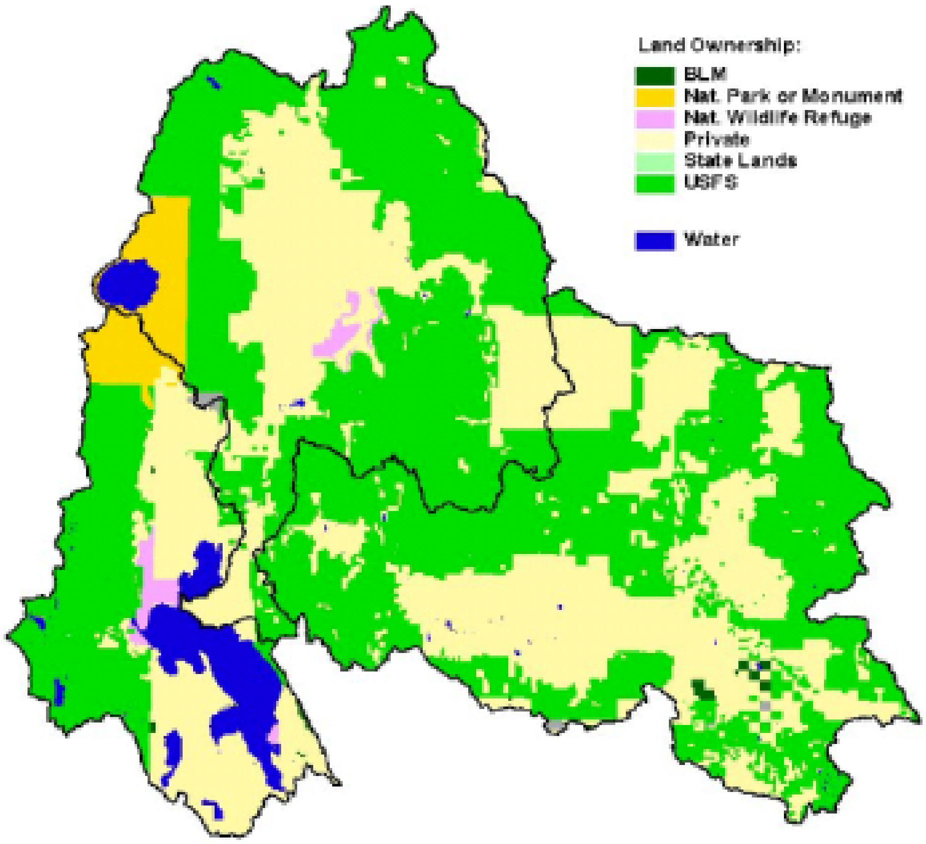

Figure 3. Plan view of land ownership in the Upper Klamath Basin (Source, 2002)

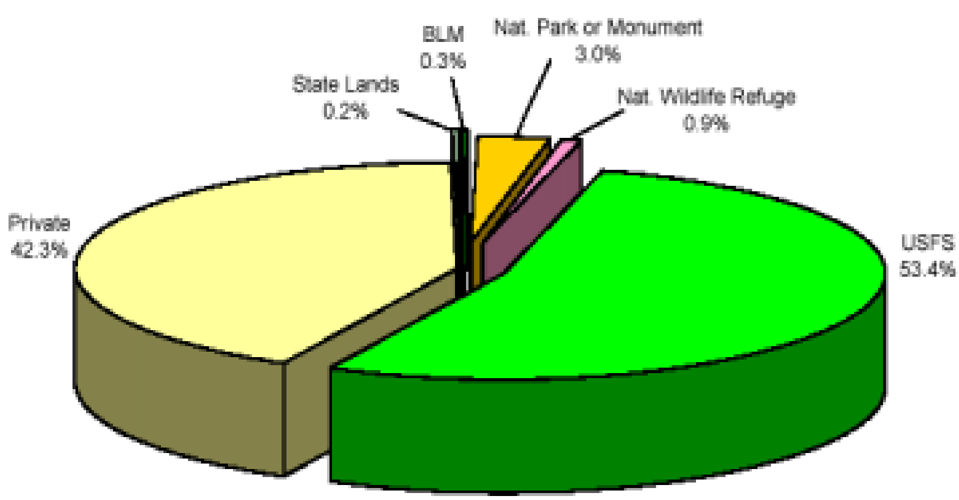

Figure 4. Land Ownership in the Upper Klamath Basin (Source ODEQ, 2002).

2.2 Geology, Landform, and Hydrology

The Upper Klamath River Basin is bounded by the Cascade geologic province on the west and high volcanic plateaus and basin and range topography on the north, east, and south. The west side of the watershed is within the High Cascades geologic province. High shield and strato-volcanos characterize this area. The dominant feature of the volcanic plateaus and eruptive centers to the east of the High Cascades is the deep deposit of pumice from the eruption of Mt. Mazama some 7,000 years ago. Streams in this area consist of both spring-fed and snowmelt dominated systems. Snowmelt runoff streams typically peak in mid-spring to early summer, with lowest flows occurring in August or September. Spring-fed streams such as the upper Williamson, the Wood River, and Spring Creek may show a slight increase in streamflow in response to snowmelt, however in general they maintain higher baseflows in late summer.

The Upper Klamath Basin headwaters are located in the higher elevation coniferous forests and meadows of the Fremont and Winema National Forests, and to a lesser extent in Crater Lake National Park. The Sycan River, and North and South Forks of the Sprague River drain the eastern margins of the Upper Basin. The Williamson River and many smaller drainages including the Wood River and Sevenmile Creek headin the Cascade Range and flow directly into Upper Klamath Lake. The highest point in the UKB is 9,490 feet in elevation. The Williamson River enters Upper Klamath Lake at about 4,000 feet above sea level. Shaded relief topography is depicted in Figure 5.

Upper Klamath Lake is in a large, flat valley located at the extreme northwestern margin of the Basin and Range physiographic province, adjacent to the eastern slopes of the Cascade Range in south-central Oregon. It is the largest lake (by area) within Oregon, having a surface area of about 140 square miles at maximum lake surface elevation, a length of about 25 miles, and ranging in width from 2.5 to 12.5 miles. Despite its large size, the lake is shallow and has a mean summer depth of about 8 feet and a maximum depth of about 58 feet. Agency Lake adjoins the northern portion of Upper Klamath Lake, though it is somewhat separated from the larger lake by the Williamson River delta. Agency Lake is also shallow, and has a surface area of approximately 14 square miles.

The principal tributaries to the lake are the Williamson and Wood Rivers. The Williamson River is the largest, with much of its flow derived from the Sprague River. The Williamson River subbasin and the Sprague River subbasin have a drainage area of approximately 3,000 square miles (1,920,000 acres) comprising 79 % of the total drainage area that contributes to Upper Klamath Lake. The Sprague River has a drainage area of 1,580 square miles (1,011,000 acres) comprising 53 % of the Williamson River subbasin. Together, the Williamson and Sprague Rivers supply about one-half of the inflow to Upper Klamath Lake.

When streams are at baseflow, conditions are often optimal for solar heating and consequently higher stream temperatures. Low flows in UKB streams generally occur during the end of the summer months (July to October) due to decreasing precipitation and increased agriculture water withdrawals. Many streams in the UKB have summer withdrawals for irrigation that lower streamflows. However, in the UKB a few FS streams are affected by irrigation withdrawals on FS lands. BLM lands are affected by withdrawals on several streams.

Relatively little historical flow data exists for the Upper Klamath Lake drainage. Six USGS gages on the Sycan, Sprague, and Williamson Rivers have recorded enough historical daily values to calculate Log Pearson Type III 7Q10 low flows. This is the 7 day averaged low flow condition that occurs with a 10 year return interval, calculated with a Log Pearson type III distribution. Table 2 summarizes the 7Q10 low flows (ODEQ, 2002), and the gage locations and periods of record. It is extremely likely that 7Q10 low flows in the lower portions of the drainage are impacted (i.e., lowered) by upstream diversions.

Table 2. 7-day average low flow conditions that occur within a 10-year time interval, calculated with a log-Pearson type III distribution (ODEQ 2002).

Low Flow Averaged over 7 days with a Return Period of 10 Years				
Stream	**Location**	**Period**	**River Mile**	**7Q10 Low Flows (cfs)**
Sycan River	Below Snake Creek	1978-1991	3.0	8.4
Sprague River	Near Beatty, OR	1953-1991	75.1	76.2
Sprague River	Near Chiloquin, OR	1921-1999	5.4	120.2
Williamson River	Below Sheep Creek	1978-1991	67.8	37.8
Williamson River	Near Klamath Agency, OR	1954-1995	27.0	0
Williamson River	Below Sprague River	1923-1999	11.0	390.4

In addition to streams, spring flow and groundwater seepage provide continuous inflow to Upper Klamath Lake throughout the year (Illian, 1970). Springs that contribute colder flows to streams provide cold water refugia that are important for providing habitat during periods of lower streamflow and higher stream temperatures. These inflows can range from less than 1 cfs to over 100 cfs. Figure 6 shows a Forward Looking Infrared Radiometry (FLIR) aerial photograph of a cold water inflow into the upper Williamson River.

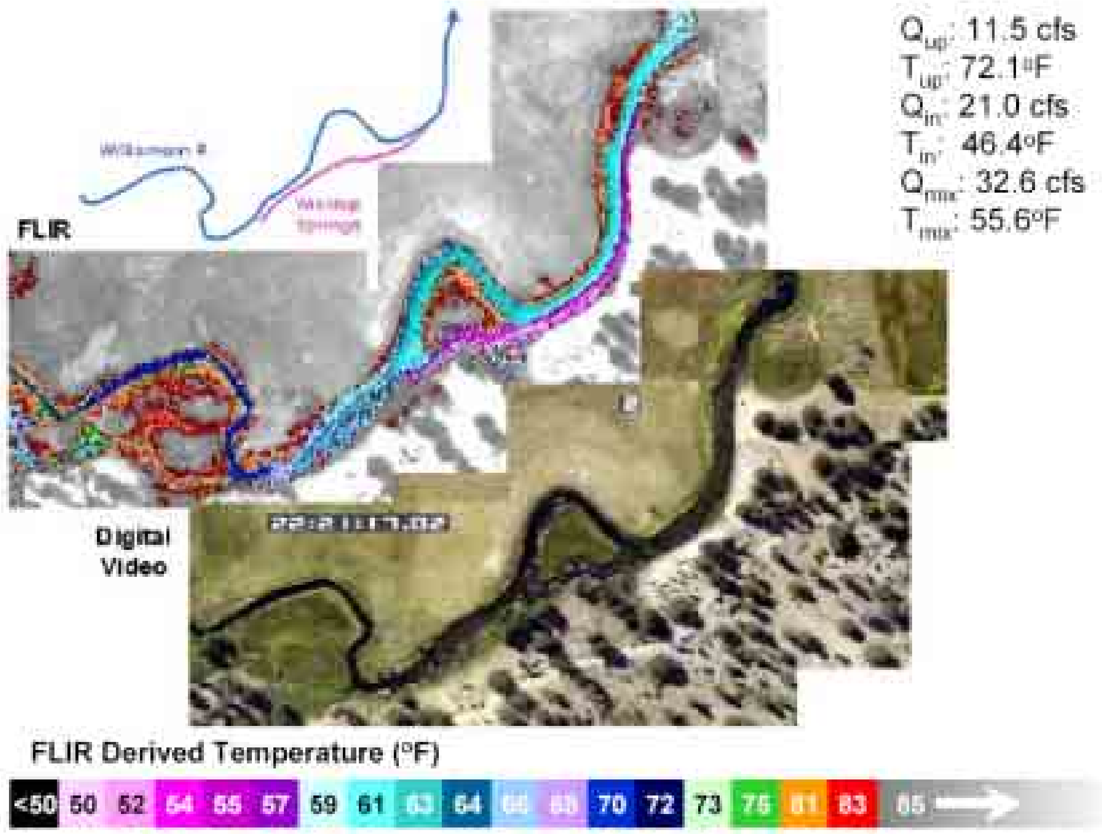

Figure 5. Forward looking infrared imagery of the confluence of upper Williamson River and Wickiup Springs. The springs are approximately 10 degrees colder than the river (ODEQ 2002).

2.3 Climate

The climate of the UKB is generally characterized by warm, dry summers and wet winters with moderately low temperatures. It is located on the drier, east side of the Cascade Mountain Range, and is in the path of storms originating in the north Pacific Ocean. Winter rain and snow is derived from these storms when they track in an easterly direction. The Cascade Range creates a rain shadow that affects the distribution of precipitation throughout the Upper Klamath Lake drainage. Annual precipitation (Figure 7) in the basin ranges from lows of 15 inches at Upper Klamath Lake and along the Sprague River to highs reaching 90 inches at Crater Lake (Daly et al, 1997). The 30-year averaged mean annual precipitation for the Upper Klamath Lake subbasin is 27 inches. However, precipitation amounts can vary significantly from year to year. The mean annual precipitation is 23 inches in the Williamson River subbasin upstream from the confluence with the Sprague River and 20 inches in the Sprague River subbasin. Mean annual snow accumulation ranges from 15 inches in the valleys to more than 500 inches in the mountainous areas of the basin. Snowfall represents 30 % of the annual precipitation in the valleys and more than 50 % of the total at higher elevations.

Table 3. Average Monthly Climate Data for Chiloquin, Oregon

Parameter	Jan	Feb	Mar	April	May	Jun	July	Aug	Sept	Oct	Nov	Dec	Year
Air Temperature (°F)													
Mean	27.2	30.1	37.4	43.5	48.5	55.9	61.0	61.1	53.8	45.8	34.8	27.5	44.1
Maximum	36.4	40.4	48.5	57.7	64.3	72.7	79.8	80.5	71.9	62.1	44.8	36.2	58.2
Minimum	17.9	19.8	26.3	29.3	32.6	39.1	42.3	41.8	35.7	29.6	24.8	18.7	30.1
Precipitation (inches)													
Mean	2.4	2.83	2.47	1.30	1.29	.65	.61	.57	.82	1.23	3.18	3.59	21.8

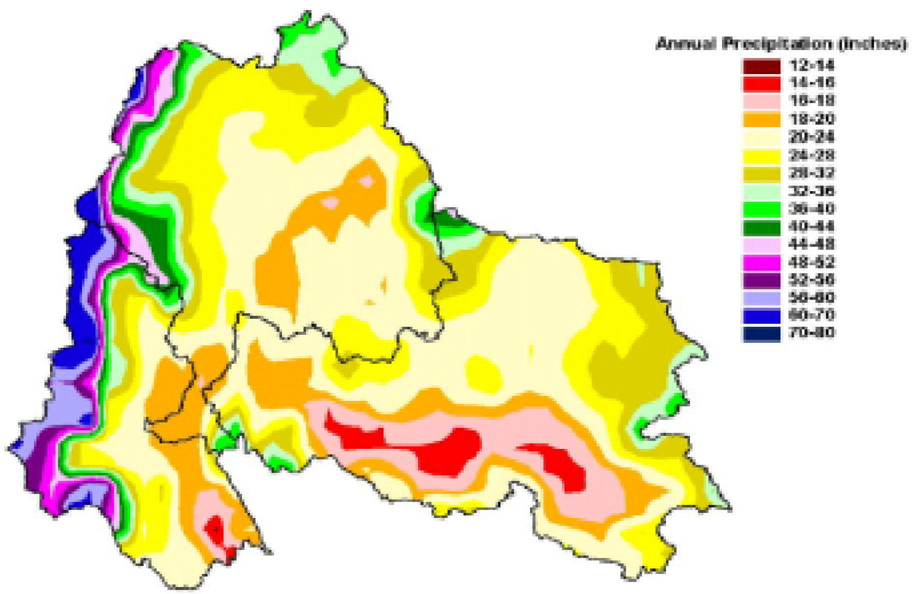

Figure 6. Annual precipitation in the Upper Klamath Basin (Source ODEQ 2002)

2.4 Water Quality Standards and Beneficial Uses

The temperature standard applicable to most streams in the Upper Klamath Lake drainage mandates that no measurable surface water temperature increase resulting from anthropogenic activities is allowed. Further, it reads the Oregon Administrative Rules (OAR)340-41-0965(2)(b)(A) specify that:

To accomplish the goals identified in OAR 340-041-0120(11), unless specifically allowed under a Department-approved surface water temperature management plan as required under OAR 340-041-0026(3)(a)(D), no measurable surface water temperature increase resulting from anthropogenic activities is allowed: (viii) In a basin for which salmonid fish rearing is a designated beneficial use, and in which surface water temperatures exceed 64.0°F (17.8°C); (ix) In waters and periods of the year determined by the Department to support native salmonid spawning, egg incubation, and fry

emergence from the egg and from the gravels in a basin which exceeds 55.0°F (12.8°C); (x) In waters determined by the Department to support or to be necessary to maintain the viability of native Oregon bull trout, when surface water temperatures exceed 50.0°F (10.0°C); (xi) In waters determined by the Department to be ecologically significant cold-water refugia; (xii) In stream segments containing federally listed Threatened and Endangered species if the increase would impair the biological integrity of the Threatened and Endangered population; (xiii) In Oregon waters when the dissolved oxygen (DO) levels are within 0.5 mg/l or 10 % saturation of the water column or intergravel DO criterion for a given stream reach or subbasin;
(xiv) In natural lakes.

Table 4. Beneficial Uses for surface waters in the Upper Klamath Basin.

Beneficial Use	***Occurring***	***Beneficial Use***	***Occurring***
Public Domestic Water Supply	YES	Salmonid Fish Spawning(trout)	YES
Private Domestic Water Supply	YES	Salmonid Fish Rearing(trout)	YES
Industrial Water Supply	YES	Resident Fish and Aquatic Life	YES
Irrigation	YES	Wildlife and Hunting	YES
Livestock Watering	YES	Fishing	YES
Boating	YES	Water Contact Recreation	YES
Hydro Power	YES	Commercial Nav./Transport	YES
Aesthetic Quality	YES		

2.4.1 Beneficial Uses Affected

Beneficial uses and the associated water quality standards are generally applicable drainage-wide. At a minimum, uses are considered attainable wherever feasible or wherever attained historically. Beneficial uses identified by DEQ for waterbodies in the Upper Klamath River Basin are salmonid spawning and rearing, resident fish and aquatic life, public and domestic water supply, irrigation, industrial water supply, livestock watering, fishing, wildlife, water contact recreation, hydro power. Of the beneficial uses, three (salmonid spawning, salmonid rearing, and resident fish and aquatic life) are sensitive to water temperature. The most sensitive beneficial use for the UKB is salmonid spawning and rearing.

Numeric and narrative standards are designed to protect the most sensitive beneficial uses. These standards are discussed in the Upper Klamath Lake Drainage Total Maximum Daily Load Allocation (UKL TMDL, Section 2.3, pages 33 to 35; and Section 3.2, pages 81 to 84) (ODEQ, 2002).

2.5. 303(d) Listed Waterbodies

Section 303(d) of the Federal Clean Water Act (1972) requires that water bodies that violate water quality standards, thereby failing to fully protect *beneficial uses*, be identified and placed on a 303(d) list. The Upper Klamath Lake drainage has 20 streams on the 1998 303(d) list for water temperature standards violations (Table 6 and figure 8). These streams have segments that were listed based upon the 64^{o} F rearing criteria for salmonid fish rearing, or the 50^{o} bull trout viability criteria. Some streams are listed from the mouth to headwaters, while others have multiple segments that are listed. These segments are identified by geographic landmarks.

In addition to the listed stream segments, Upper Klamath Lake and Agency Lake are included on the 1998 303(d) list for not meeting state water quality standards for dissolved oxygen (DO), Chlorophyll-a, and pH.

Figure 7. Streams listed on the 303(d) list in the Upper Klamath Basin (Source ODEQ 2002).

2.5.1 Sprague River Sub-Basin

In the Sprague River Sub-basin 17 streams and 21 stream segments are listed on the 303(d) list. Exceedences of water quality standards can be linked directly to past and present management activities on National Forest lands as well as to natural background conditions. Listed streams include smaller 2nd to 3rd stream order drainages, and larger 4th and 5th order stream segments. Nineteen stream segments are listed for exceeding the temperature standard. Fifteen of these stream segments are listed because they exceed the 64^0 F. numeric temperature criteria where salmonid fish rearing is a designated beneficial use, and four are listed because they exceed the 50^0 F. numeric criteria for maintaining the viability of bull trout, a species that is highly sensitive to higher stream temperatures.

The Sprague River from the mouth upstream to the confluence with the North and South Fork Sprague is also listed for summer pH and dissolved oxygen. Many of the smaller, 2nd to 3rd stream order headwater streams in this sub-basin are located on the Fremont or Winema National Forests. Small ephemeral or intermittent tributaries to the South Fork of the Sprague River, Fishhole Creek, and Deming Creek occur on BLM land. These streams do not support substantial riparian areas. Long sections of the lower Sprague and Sycan Rivers are located on private land, and are not covered under this plan.

2.5.2 Upper Klamath Lake Sub-Basin

Three stream segments are listed on the 303(d) list in the Upper Klamath Lake Sub-Basin. Rock Creek and the lower portion of Fourmile Creek are listed for temperature, based on the 64^o F spawning and rearing criteria. Rock Creek flows primarily on National Forest system land, while much of the lower portion of Fourmile Creek flows across land administered by the BLM. This 1,200 acre parcel has been evaluated as a potential Area of Critical Environmental Concern (ACEC), and was found to meet the “relevance and importance” criteria (BLM, 2000). For the parcel to be designated an ACEC, an amendment to the KFRA RMP and an associated Record of Decision would have to be prepared.

Rock Creek and Threemile Creek are listed on the 303(d) list for habitat modification. Habitat modification is not a water pollutant, and is not covered by the TMDL or this water quality restoration plan. However, the Winema National Forest is actively working to restore the aquatic habitat in these watersheds. These streams are primarily located on the Winema National Forest, with small sections located on private property. Information gathered in surveys of each of these streams shows there is a lack of large wood in the channels. The lack of wood has resulted in deteriorated conditions in these streams. These streams have roads that were constructed parallel and adjacent to the channels. In the past large logs that were deposited in the channels were removed. At the time of removal, these logs were perceived as being detrimental to the channels. Recruitment of new wood for the channels is dependent on the ability to grow large trees in the adjacent riparian areas. Growing trees large enough to provide shade and increased downed woody debris is a process that requires many decades. The FS has an active restoration program with a goal to provide improved habitat conditions on these streams.

2.5.3 Williamson River Sub-basin

Three stream segments are listed for exceeding the water quality standard for temperature. These three segments are on the Williamson River, above and below Klamath Marsh. Segments of the Williamson, especially that section located above Klamath Marsh, has reduced amounts of shade-producing shrubs compared to historical conditions. Shrubs, especially willows, have been removed and channel widening or entrenchment has occurred due to a variety of land use impacts. Much of the upper and lower Williamson flows through private land. The BLM does not administer any of the area within this sub-basin.

Table 5. Miles of water quality limited streams in the Upper Klamath River Basin (Source 1998 303(d) list)

Miles of 303(d) List Streams by Ownership	
Private	311
Fremont National Forest	92
State of Oregon	30
Winema National Forest	71
BLM Klamath Falls Resource Area	< 1
Unknown	0.3
U.S. Fish and Wildlife Service	0.1

Table 6. Klamath Basin streams on the 303(d) list for violation of the stream temperature standard (source ODEQ 2002).

Subbasin Name	Stream Name	Segment Listed
Sprague	Boulder Creek	Mouth to Headwaters
Sprague	Brownsworth Creek	Mouth to Hammond Creek
Sprague	Brownsworth Creek	Hammond Creek to Headwaters
Sprague	Buckboard Creek	Mouth to Headwaters
Sprague	Calahan Creek	Mouth to Hammond Creek
Sprague	Coyote Creek	Mouth to Headwaters
Sprague	Deming Creek	Mouth to Campbell Reservoir Diversion
Sprague	Deming Creek	Campbell Reservoir Diversion to Headwaters
Sprague	Fishhole Creek	Mouth to Headwaters
Sprague	Fivemile Creek	Mouth to Headwaters
Sprague	Leonard Creek	Mouth to Headwaters
Sprague	Long Creek (Sycan Marsh)	Sycan Marsh to Calahan Creek
Sprague	Paradise Creek	Mouth to Headwaters
Sprague	Pothole Creek	Mouth to Headwaters
Sprague	Sprague River	Mouth to North/South Fork
Sprague	Sprague River, North Fork	Mouth to Dead Cow Creek
Sprague	Sprague River, South Fork	Mouth to Camp Creek
Sprague	Sycan River	Mouth to Rock Creek
Sprague	Trout Creek	Mouth to Headwaters
Williamson	Williamson River	Mouth to Sprague River
Williamson	Williamson River	Sprague River to Klamath Marsh
Williamson	Williamson River	Klamath Marsh to Headwaters
Upper Klamath Lake	Fourmile Creek	Mouth to RM 1
Upper Klamath Lake	Rock Creek	Mouth to Headwaters

2.6 Land Management Impacts: Streams, Wetlands and Riparian Areas

Streams in the UKB have been influenced by an increase in solar radiation reaching the stream surface due to land management. Logging, intensive un-controlled grazing, or road construction (Brown and Krygier, 1970, Brown, 1980) can cause significant increases in stream temperature, and are among the human-caused impacts that have influenced stream temperatures. As a result, past management activities along streams in the watershed have left a mosaic of vegetation age classes in riparian areas. Natural disturbances such as flooding, channel migration, fire, and insect damage and disease are inherent in the development of natural riparian plant communities. Riparian areas and stream channels are dynamic environments, and channels and plant communities reflect the complex interplay of multiple disturbances distributed in time and space. As a result of the collective impacts of human-caused and natural disturbances, many of the UKB streams are over-widened, lack substantial amounts of riparian vegetation and have inadequate amounts of shade. Water flowing through these areas exhibits elevated temperatures after being exposed to increased amounts of solar radiation. The effects of reduced stream shading are amplified when streamflows are reduced by diversions or impoundments.

Upper Klamath Lake and Agency Lake are hyper-eutrophic lakes that support an abundant algal population. Lake water quality varies according to season and the annual amount of runoff entering the lake. Recent studies have pointed out that the nutrient-enriched condition of the lake, though natural, has likely been accentuated as a result of agricultural activities, livestock production, logging, urban development, and reclamation of wetlands for agriculture (Eilers et al. 2001, Snyder and Morace 1997). Massive blooms of blue-green algae typically occur in the lake in the summer. Daily cycles of respiration and decomposition result in extremely high pH levels and wide fluctuations in levels of dissolved oxygen and carbonic acid.

Some aspects of wetland function have been restored to large areas of reclaimed wetlands. The first of these restoration projects began in 1995, at the Wood River Wetland. Due to reduced pumping rates and enhanced nutrient storage function, wetland restoration can reduce nutrient loading to the lakes. Currently, pumping from the Wood River Wetland stops in spring (BLM 1999; BLM 2001).

2.6.1 Livestock Grazing

Historic un-controlled livestock grazing has been a significant factor in changing riparian areas. These impacts are far-reaching in space and time, and impacts from historic grazing, such as changes in riparian vegetation communities, bank trampling and sloughing, and poor channel conditions that may directly influence stream temperatures can persist for decades and can be extensive. Cattle tend to congregate in riparian areas especially later in the growing season when upland forage has cured and is no longer palatable. Also, upland water sources are less available as ponds and stock tanks dry up, tending to draw cattle towards riparian areas in late summer.

During early settlement periods grazing was extensive on the National Forests. Records indicate season long grazing was the rule and extended for up to 8 months of the year. Livestock Animal Unit Months (AUM's) in 1910 were approximately 450,000 and have since been reduced to 71,000 on the forests. Following the intensive livestock grazing that occurred in the late 1800's and early 1900's, allotment management plans (AMP's) were implemented by the FS, and riparian conditions improved. In 1990, all grazing permits on the forests were modified to incorporate grazing standards and guides specified in the Winema and Fremont forest plans and BLM rangeland standards. These standards were further defined and strengthened when the Forest grazing program was consulted on with the U.S. Fish and Wildlife Service (USFWS) in 1997. Presently the Winema and Fremont Forest Plan standards and guides, and terms and conditions of the USFWS Biological Opinion on grazing are being applied.

Monitoring has shown current riparian and channel conditions on most allotments are improving. Implementation and effectiveness monitoring are done regularly for grazing allotments. Information is used by permittees and forest personnel to determine when livestock should be moved to ensure that utilization thresholds are not exceeded. Utilization thresholds were identified in the Fremont and Winema Forest Plans and in USFWS Biological Opinions to ensure continual recovery of riparian areas.

The BLM lands in the Sprague River sub-basin are intermingled with privately owned lands. They are currently grazed at a capacity of 15-18 acres/AUM. The grazing history of these lands is probably similar to most BLM lands - extensive uncontrolled grazing and resultant overgrazing during the settlement (pre-Taylor Grazing Act of 1934) era; gradual regulation, control, and reduction of grazing use during the middle portions of the 20th century; and stability at much lessened stocking rates with periodic assessment during recent decades.

Wetlands administered by the BLM in the Agency Lake area are contained in two separate parcels - the Fourmile and Wood River properties. The Wood River Ranch was purchased by the BLM in 1993 and 1994. The property was intensively grazed by livestock (i.e. 6-8 AUMs/acre) since the area was reclaimed in the late 1940's and early 1950's. After the 1994 season, the grazing leases were not renewed and the property has remained un-grazed since then.

Fourmile was managed by the Bureau of Reclamation for many years, but transferred to BLM administration in 1994. Similar to Wood River, the property was grazed fairly intensively (i.e. 2-3 AUMs/acre) since at least 1938 under competitive grazing leases issued by the USBR. Since the BLM has administered the property, no authorized grazing has occurred though some trespass cattle use has occurred periodically.

2.6.2 Roads and Timber Harvest

Timber harvest and associated roads have probably impacted peak flood flows in logged watersheds and increased sediment delivery from logged watersheds in the UKB. However, site-specific conclusive information is not available on the magnitude of flow or sediment yields as a result of harvest activities in the UKB. Studies from other similar areas provide insight into the range and magnitude of effects of timber harvest on watersheds. A paired watershed study from the Umatilla National Forest in an area with similar climate, vegetation, and geology in the Blue Mountains of Oregon (Helvey and Fowler, 1995) has shown increases in suspended sediment, increases in annual water yield, peak flows, and earlier snowmelt peaks after timber harvest.

Numerous studies have shown that forest roads can have a significant impact on the hydrology and sediment yield of forested watersheds. Interim results from the ongoing Spencer Creek Road Inventory (a cooperative BLM/USFS study in a watershed tributary to the Klamath River) indicate that sediment production from surfaced roads is on the order of 0.2 pounds per 100 ft^2 of road surface, while unsurfaced roads may produce an order of magnitude more sediment for the same surface area (BLM, 2002a). Wemple et. al. (1996) found that nearly 60% of the road network in study watersheds in the western Cascades drained into streams and gullies. In turn, roads can serve as a link between sediment source areas and stream channels. Forest road impacts to hydrology and sediment yield are often correlated with road density and the number of stream crossings (see Table 7). Additionally, the connectivity between roads and streams can be affected by soil conditions, slope steepness, and road standards.

Table 7. Summary of miles of roads located within 2 buffer widths of streams, and stream crossing density for lands in the Upper Klamath Basin on the Winema and Fremont National Forests

	Winema National Forest		**Fremont National Forest**	
Roads within 640 ft of streams	**Total UKB Roads (miles)**	**Roads on NF (miles)**	**Total UKB Roads (miles)**	**Roads on NF (miles)**
Perennial Streams	144	121	126	111
Intermittent Streams	114	109	414	380
Ephemeral Streams	1098	1046	275	251
Roads within 1280 ft of streams				
Perennial Streams	285	240	252	226
Intermittent Streams	237	228	762	696
Ephemeral Streams	2082	1986	599	544
Roads/Stream Crossings	**Total UKB Crossings (#)**	**Crossings on NF (#)**	**Total UKB Crossings (#)**	**Crossings on NF (#)**
Perennial Streams	115	109	156	142
Intermittent Streams	138	133	872	820
Ephemeral Streams	1822	1758	554	505

Timber harvest has historically occurred along many forested riparian areas on FS land in the UKB. This has resulted in decreased shade in riparian areas where harvest has occurred. Additionally, fire exclusion in riparian areas due to widespread fire suppression over the last several decades and exclusion of riparian areas from timber harvest has led to generally more abundant trees and undergrowth than historical conditions. As a result of past timber harvest practices and fire suppression, often a mosaic of vegetation age classes typifies riparian areas along streams. Further, typically timber harvest units have been replaced with planted trees and dense understories of ponderosa pine and white fir. Following timber harvest, these dense stands of younger, shorter trees generally provide less shade than mature site potential trees. Where mature site potential trees are present in forested riparian areas they contribute substantial amounts of shade to streams. Not all riparian areas were intensely harvested before riparian protections were in place. As a result, some areas still retain conifers and hardwood species large enough to provide substantial shade to streams. Many harvested riparian areas will require years or decades to reach riparian and channel conditions that will provide shade in amounts that will allow for lower stream temperatures.

2.6.3 Stream Channels and Riparian Vegetation

Physical processes shape stream channels within a given drainage basin. These physical processes are the natural result of interrelated landscape and instream characteristics and interactions. Key parameters that affect stream channel evolution are the character and condition of near-stream riparian vegetation, nature of channel substrate and sediment loads, and streamflow magnitude, frequency and duration. Stream channels, over time, reach dynamic equilibrium with flow, sediment transport processes, and streamside vegetation. Human land uses can alter these factors and processes, and in the UKB have altered stream channel conditions. Human land use can directly and indirectly change the near stream vegetation type and condition. Flow augmentation and withdrawal can change stream flow patterns. Erosion and depositional processes can increase from various upland and instream human activities.

Channel conditions help determine the amount of solar radiation a stream receives, and can be a significant influence on stream temperature patterns. Channel widening can result from changes in flow and sediment yield, or channels can adjust in response to changes in streamside riparian communities. Increased width to depth ratios of channels as a result of channel widening is a major factor in determining the thermal regimes of streams. Floodplain condition is another important component of channels. Floodplains help dissipate streamflow energy as streams go over their banks. As water infiltrates into floodplains, cooler flows may return to the stream and help to reduce stream temperatures (Lowry, 1993). As streams downcut in response to disturbances, they tend to lose connection with floodplains, and lose an important moderating effect on temperature. In some areas, water table lowering associated with downcutting can lead to conversion of near stream plant communities from riparian types (dominated by shrubs and well-rooted sedges and rushes) to types more typical of uplands (dominated by silver sage and conifers).

Patterns of flow and sediment transport through a watershed result in channels adjusted to the rate of sediment and flow supplied to them. Riparian habitats were in turn shaped by the interaction of channel forming processes such as sediment deposition and flow patterns. In fact, many riparian plant species, in order to get established, require bare ground created by large floods. These un-vegetated areas near channels create little shade, yet are important for future recruitment of shade producing species such as willow and cottonwood.

<u>Fluvial Processes in Geomorphology</u> (Leopold et. al. 1964) presents a wide-range of settings for common hillslope and stream landform patterns shaped by water flow. For example, riffles and associated gravel bars tend to occur at intervals of 5-7 channel widths along streams. The ecological status or seral stage of riparian habitat along streams then is likely to reflect fluvial processes with low status vegetation on newly scoured bars, mid-status on the upper part of bars, and high status vegetation on the floodplain and streambanks. For example, Weixelman

(1999) found that mid status habitats tend to dominate active fluvial surfaces on the middle to upper portions of bars. They classified riparian vegetation into three ecological status classes. These are early, mid, and late, and are composed of a community of plants that reflect local ecological gradients such as soil moisture and the fluvial setting. The distribution of these ecological status classes on a landscape scale tend be nearly a normal distribution, with about 70% of sites in mid, 15% in early, and 15% in late for most areas.

The morphology of stream channels reflects a variety of impacts in the Upper Klamath Sub-Basin. Livestock grazing, in combination with other impacts, in many areas has helped cause over-widened and degraded channels. By changing the character and composition of riparian vegetation, poor grazing management can cause deteriorated stream channel conditions. Sediment delivery and increased flows derived from roads and other watershed impacts can also directly impact channels. Changes that can result include accelerated bank erosion, increased width/depth ratios, altered channel patterns, decreased channel stability, increased sediment supply, and poor fisheries habitat. Excess fine sediments can fill the pore space between coarser substrates, thereby reducing the cooling effect of subsurface flow through streambed alluvium (Poole et al., 2001). Timber harvest can remove large trees along riparian areas that are sources of shade and large wood to streams. Large wood in channels helps store and route sediment through channels, act as grade controls for channels, and help provide pools and other important habitat for fish.

2.6.4 Rosgen Steam Channel Classifications

Rosgen (Rosgen 1996) stream type classifications (figure 9) have been done on UKB streams (ODEQ 2002) and have been used to assess stream channel evolution and condition. As part of developing system shade potential, target stream channel widths have been determined in the Upper Klamath Lake Total Maximum Daily Load Allocation (UKL TMDL) for different Rosgen stream types (ODEQ, 2002). System potential channel widths are those widths that when evaluated in combination with system potential land cover will meet the effective shade target, attain the applicable stream temperature standard and fully support beneficial uses.

Stream channels, over time, reach dynamic equilibrium with flow, sediment transport processes, and streamside vegetation. Often human land use can alter these parameters and processes, and in turn, alter stream channel conditions. The FS has completed stream surveys designed to assess stream channel morphology using the Rosgen stream classification system. A, B, C, and E type channels were considered to be in a more stable condition with little potential for evolution to another stream type (assuming that the current land use regime does not change substantially). D type channels are braided as a result of either natural or human-caused disturbance. Generally, F channel types for UKB streams were considered to have high width to depth ratios. Through channel adjustment and active or passive restoration, D and F channel types would eventually adjust to C or E channels, depending on drainage area.

Figure 9 shows Rosgen level 1 channels for mainstem drainages in the UKB. Lower Fourmile Creek is a C channel type (unpublished BLM field data).

Channel bankfull width is a fundamental factor in determining a streams solar heating potential and ultimately its thermal regime. Many other factors that can influence stream heating are directly influenced by channel bankfull width (for instance, water depth and the effect of shade). Using aerial photographs, existing streamside disturbance zones, which generally correspond to bankfull widths were estimated by ODEQ (2002) for UKB streams by Rosgen stream type (Rosgen 1996). These were done so that target bankfull widths could be established for different Rosgen level 1 stream types. In their evaluation of stream channel conditions, ODEQ (2002) found that many sections of mainstem UKB streams are wider than their expected bankfull width. For more information on how bankfull widths were estimated, see ODEQ (2002).

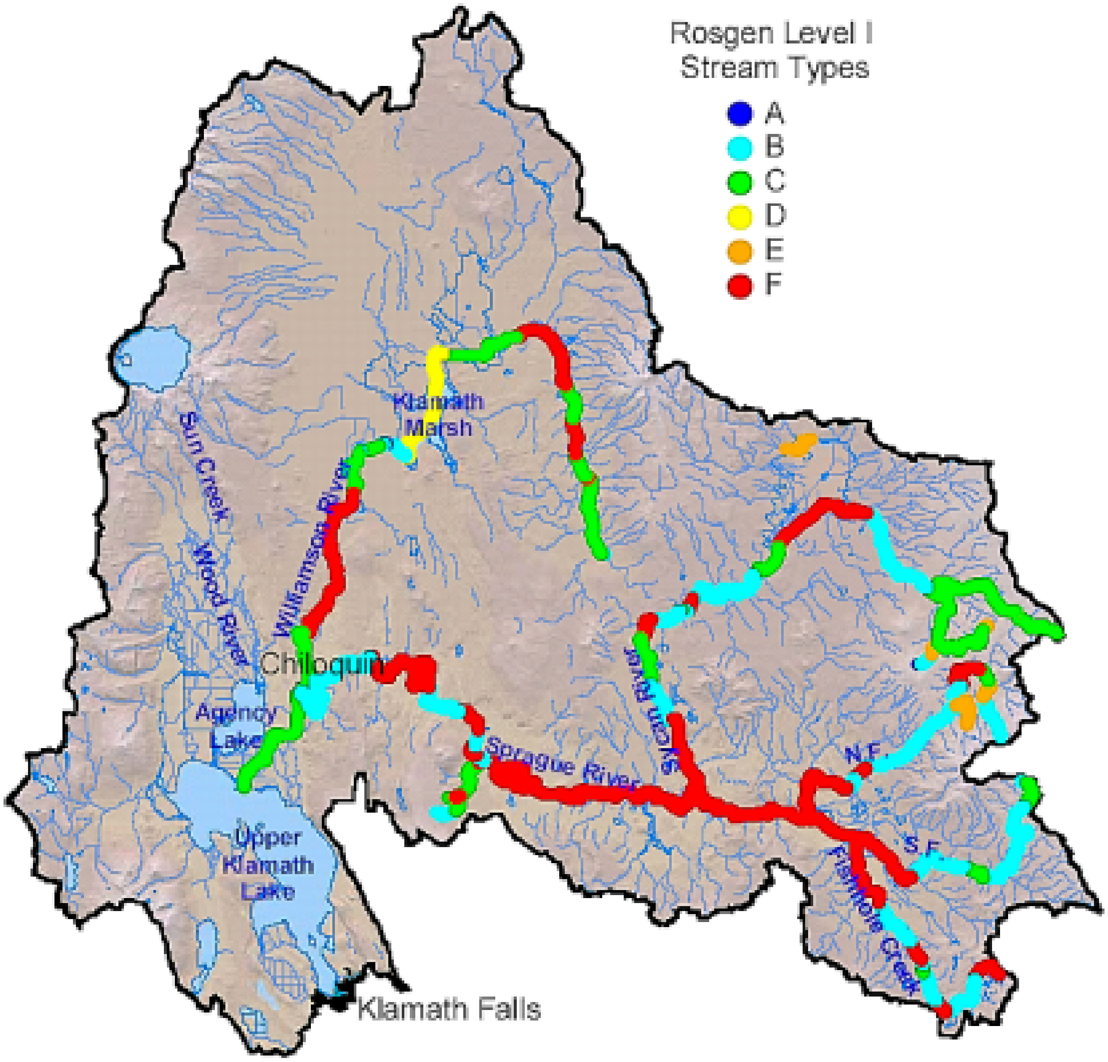

Figure 8. Rosgen stream types in the UKB (ODEQ 2002). D and F type channels generally indicate unstable channel conditions and are considered below potential for width to depth ratios.

2.7 Stream Temperature

The primary environmental factors that influence stream temperature include local air temperature, direct solar radiation, stream depth, groundwater inflow, and riparian canopy (Adams and Sullivan, 1990). These variables can vary in importance longitudinally along a stream relative to environmental conditions. Brown (1969) identified net solar radiation as the main source of heat for streams, and particularly emphasized the importance of riparian vegetation in regulating solar inputs. Brown (1983) emphasized the importance of stream surface area exposed to solar radiation, and the amount of discharge present in the stream as important variables for determining solar energy loading to streams. Solar energy directly striking the water surface was found to be the main source of heat for smaller streams. Generally, wide shallow streams, when exposed to sunlight, tend to heat up more quickly than narrow streams with the same discharge. In other words, heat gained is directly proportional to stream surface area. Further, for the same solar energy input and surface area, the temperature change for a low discharge stream will be greater than that of a high discharge stream (Beschta et al., 1987).

Because direct solar radiation is the primary energy input to smaller streams, the condition of the riparian canopy and its ability to regulate solar radiation is important for moderating the solar energy input to streams, especially during the summer months (Beschta et al., 1987). A structurally intact continuous riparian canopy is highly effective at reducing inputs of solar radiation to streams (Brown and Krygier, 1970) and regulating stream temperatures. In support of this, Bohle (1994) in the Grande Ronde River in northeastern Oregon and Friedrichsen (1996) on the Sprague River found that stream temperatures were lower in areas with larger amounts of stream cover in two studies of Oregon streams. In both studies, the average amount of shade provided by shrubs to streams was under 25%. Bohle (1994) found that stream cover along forested reaches exceeded 60%, while meadow streams had less than 15% average stream shade.

Adverse effects to stream temperature are cumulative over the length of a given stream. Three major mechanisms contribute to this cumulative effect: (1) the additive effect of extensive alterations to effective shade; (2) the downstream accumulation of heat that is added to the stream and is not lost or diluted with cool water; and (3) the multiplicative effects of altered upland, streamside, and riparian conditions on channel processes (discussed in Section 2.6.3) (Poole et al., 2001).

Because the streams that cross BLM land in the Sprague River sub-basin do not support substantial riparian areas, and because the streams that cross or are adjacent to BLM-administered wetland parcels near Agency Lake that are being managed for water quality benefits, the discussion of riparian shade in this and subsequent sections will apply only to National Forest system lands.

2.7.1 Stream Shade Existing Conditions

Water temperature warms as a result of increases in solar radiation loads. Effective shade is used as a surrogate measure for solar radiation loading capacity in the Upper Klamath Lake Drainage TMDL instead of actual solar loading values. Effective shade will be used in this WQRP as a surrogate measure for solar loading. Effective shade is defined as the percent reduction of potential solar radiation delivered to the stream surface. Site specific effective shade surrogates are developed to help translate the nonpoint source solar radiation heat loading allocations. The role of effective shade in the TMDL is to reduce heating by solar radiation, and to serve as an indicator of solar loading capacities.

Research has shown that shade-producing vegetation is an effective way to prevent elevated water temperatures. Studies have shown that riparian vegetation consisting of tall trees up to 100 feet back from the streams is effective in reducing solar radiation (Brazier and Brown, Beschta, et. al. FEMAT). Figure 10 shows that, in general, the cumulative effectiveness of shade from riparian vegetation in a forested environment reaches a maximum about one tree height from the channel.

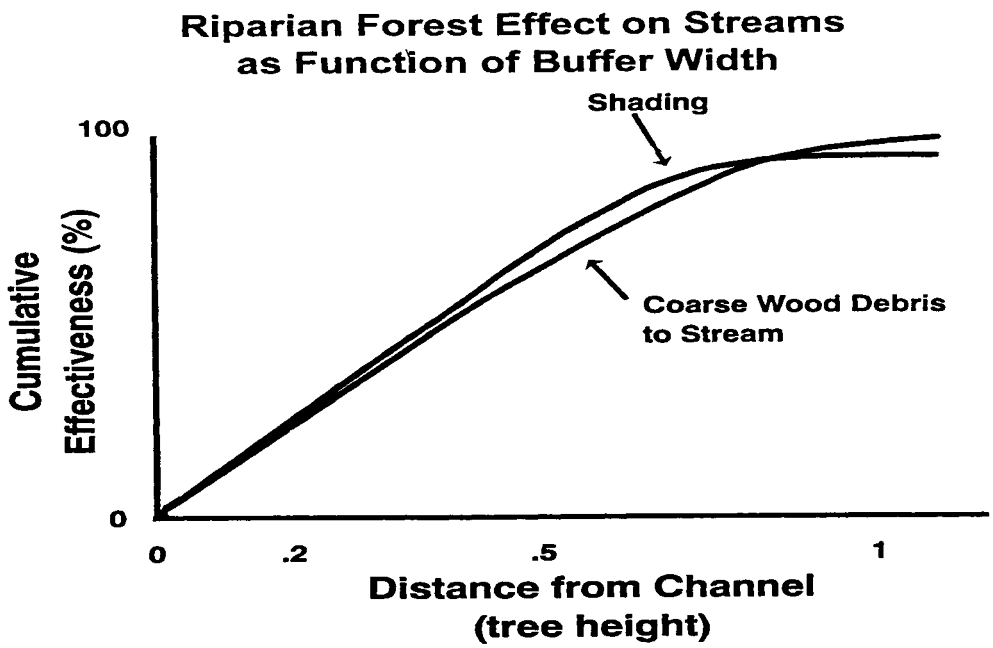

Figure 9. Riparian area or streamside buffer effectiveness as a function of tree height and distance from the stream. Maximum effectiveness of coarse woody debris inputs and stream shade occur within one tree height away from the stream. (FEMAT, page V-27).

In theory and in practice, by allowing vegetation communities in riparian areas to grow to their site ecological status potential, shade provided to streams will be increased and stream temperatures will remain cooler in response to this increased shade. The definition of ecological status potential in this WQRP is consistent with the definition of system potential land cover used in the UKL TMDL (ODEQ 2002). System potential is the combination of potential near-stream or riparian land cover conditions and potential channel morphology conditions that meets the temperature standard by increasing effective shade. Potential riparian land cover in the TMDL is the land cover that could grow and reproduce along a stream considering important site specific hydrologic, soil, and vegetative conditions. Potential channel morphology conditions in the UKL TMDL were developed using an estimate of bankfull channel widths appropriate for a given Rosgen stream channel type.

System potential land cover and channel width is the combination of land cover and bankfull channel widths that provides effective shade for 303(d) listed streams in amounts where anthropogenically elevated stream temperatures are not expected to occur.

The spatial and temporal patterns and effects of natural rates of disturbance should be considered when evaluating ecological status potential or land cover. Disturbance in turn may lead to discontinuous patterns of shade producing riparian plant species along streams. It is assumed for the UKL TMDL and this WQRP that land cover will recover readily from a natural disturbance event.

2.7.2 Riparian Shade Surveys, Random Sites

Shade surveys have been conducted by the FS specifically to measure existing effective shade. Current shade conditions were evaluated for randomly selected sites in seven different riparian vegetation community groups throughout FS land in the UKB in 1999 (McNamara et. al. 2000). Within each of the seven vegetation community groups, stream reaches were selected for measurement where the riparian vegetation reflected impacts from a variety of land management impacts, and to evaluate shade conditions across a broad range of vegetation types and channel conditions.

The types of plant community groups composing the riparian canopy along streams was a major factor in determining the amounts of riparian shade that could occur along a stream reach. The community groups that were monitored were sedge/grass, willow/shrub, alder, lodgepole pine, ponderosa pine, white fir, and cottonwood/aspen. Kovalchik (1987) and Hopkins (1979) identified riparian communities and plant associations found in central and south central Oregon. These groups represent vegetation types that typically are found together along streams in the UKB. They were derived based on the dominant species types present, and included numerous species.

Total average shade at random sites in tree-dominated communities ranged from 42 to 61%. Community groups dominated by tree species such as lodgepole pine, other conifers, cottonwoods, and aspens generally provided considerably more shade than sedge/grass and willow/shrub communities. These results are consistent with the observations of Bohle (1994) who found that densely forested streams had mean shade values over 60%. In contrast, he found meadow reaches had stream shade values of less than 15%. Average stream shade values in this study ranged from 26-31% for the types of vegetation that are typically found in meadow environments such as sedge/grass and willow/shrub community groups.

Table 8- Randomly selected shade survey sites average percent shade, maximum and minimum percent shade, sample standard deviation, and number of samples for each riparian community group, 1999 survey.

	Sedge/ Grass	Willow/ Shrub	Alder	Ctnwood/ Aspen	Lodgepole Pine	Pond. Pine	White Fir
Avg.% shade(n)	26(24)	31(15)	66(12)	61(7)	53(11)	42(10)	57(10)
Min	2	11	28	21	28	15	24
Max	64	69	89	82	70	78	87
SD	15	16	20	22	12	20	21

Table 9- Average percent shade by stream wetted width for randomly selected shade survey sites for each riparian community group. From 1 to 12 shade measurements were taken at potential and random sites within each width category, 1999 survey.

Wetted Width (ft)	Sedge/ Grass % Shade	Willow/ Shrub % Shade	Alder % Shade	Ctnwood/ Aspen % Shade	Lodgepole Pine % Shade	Pond. Pine % Shade	White Fir % Shade
0-5	32	47	74	78	64	59	52
5-15	26	27	73	65	54	49	70
15+	12	31	44	21	46	22	39

2.8 Water Quality in Upper Klamath and Agency Lakes

Upper Klamath and Agency Lakes were both eutrophic 100 years ago. Since then, important changes have occurred in the condition of forests and rangelands in the area tributary to the lakes, the extent and function of lake-margin wetlands, and the hydrology of the lakes. In concert with natural processes that supply nutrients to the lakes, human-caused changes have altered nutrient dynamics within the lakes such that the lakes are now hypereutrophic and do not fully support sensitive beneficial uses.

In Upper Klamath Lake and Agency Lake, total phosphorous is the identified pollutant that causes pH, dissolved oxygen, and chlorophyll-a water quality standard violations. The processes that link phosphorous loading with these water quality parameters are discussed in the Upper Klamath Lake Drainage TMDL (ODEQ 2002, pages 30 to 32).

Answers to important questions regarding the role of natural sources of nutrients and the direct and indirect effects of human-caused alterations are not yet known. Such questions will be addressed by a science review team convened by ODEQ (ODEQ, 2002).

About 39% of the phosphorous available for algae production in Upper Klamath Lake is supplied via external sources (i.e., not from re-suspension of lake sediments). The two major sources of external phosphorous affecting the lakes are upland sources and water routed through lake-margin wetlands (reclaimed or otherwise). Point sources and precipitation account for a small portion of phosphorous loading to the lake (less than 2%, total) (ODEQ, 2002).

2.8.1 External sources of phosphorous (uplands)

Upland sources of phosphorous include agricultural lands, pastures and rangelands, and forested areas. Although nutrient loading in runoff and return flows from agricultural lands may be high, erosion is the major process in transporting phosphorous from the watershed into the lake (ODEQ, 2002). Erosion can occur on the land surface, along the margins of stream channels, and from roads. Phosphorous loading from the Williamson and Sprague River sub-basins accounts for about 21% and 27%, respectively, of the total external phosphorous loading to the lakes (Kann and Walker 2001).

Natural springs in the UKB also supply phosphorous to the lakes. The concentration of phosphorous in water from 14 springs averages 77 parts per billion (ODEQ 2002). Springs and other miscellaneous sources account for about 10% of the external phosphorous loading to the lakes (Kann and Walker 2001).

2.8.2 External sources of phosphorous (undrained, reclaimed, and restored lake-margin wetlands)

About 39% of the external phosphorous loading to the lakes is supplied from areas that drain extensive areas of organic soils or from pumps that discharge into the lakes (Kann and Walker 2001).

Undrained wetlands on the periphery of the lakes serve as both seasonal and long-term storage areas for phosphorous and other nutrients. Plant material is slow to decay in the anaerobic conditions typical of these wetland areas, and organic matter accumulates in peat soils.

Oxidizing conditions in reclaimed wetlands make peat soils vulnerable to decomposition. As a result, nutrients that have accumulated over the past are made available for transport into the lakes (Snyder and Morace 1997). Furthermore, reclaimed wetlands may not uptake nutrients to the same degree as undrained wetlands (Geiger 2001).

Some aspects of wetland function have been restored to large areas of reclaimed wetlands. The first of these restoration projects began in 1995, at the Wood River Wetland. Due to reduced pumping rates and enhanced nutrient storage function, wetland restoration can reduce nutrient loading to the lakes (Table 10).Currently, pumping from the Wood River Wetland stops in spring (BLM 1999; BLM 2001).

Table 10. Pre- and post-restoration measurements of nutrient concentrations and estimates of nutrient loading at two pump sites in the Wood River Wetland (nutrient concentration data from Snyder and Morace, 1997 and Rykbost and Charlton, 2001).

					Measured Nutrient Concentration		Estimated Load Delivered to Agency Lake	
		Number of Samples	Average Pump Rate (cfs)	Duration of Pumping (Days)	Total Phosphorous (mg/L)	Total Kjeldahl Nitrogen (mg/L)	Total Phosphorous Load (lbs.)	Total Kjeldahl Nitrogen Load (lbs.)
Sevenmile Canal	1993-1995	6	20	60	0.93	3.3	1241	4404
	1999-2000	22	N/A	0	0.49	3.0	0	0
Wood River	1993-1995	6	20	60	0.98	2.7	1308	3603
	1999-2000	10	25	10	0.86	3.5	239	973

2.8.3 Internal loading of phosphorous to the lakes

Large amounts of phosphorous are found in the sediments at the bottom of the lakes. The re-cycling of phosphorous from the lake bed to the water column accounts for about 61% of the total loading to the lakes (Walker 2001).

In shallow well-mixed lakes such as Upper Klamath and Agency Lakes, high pH levels can cause the release of phosphorous that is sorbed to sediment. Positive feedback loops occur in late summer, when high algal productivity creates elevated pH levels, which cause the release of phosphorous and further enhance algal productivity (Kann 1998).

2.9 Ecological Status

Ecological status evaluations are a way to evaluate key physical and biological variables in riparian areas that can help land managers identify areas at risk for water quality impairment and areas that may require restoration. Monitoring ecological status is important for helping to determine the ecological health, status, and function of riparian areas.

Federal lands in the UKB have been and continue to be monitored and evaluated to determine their ecological status. The basic objective of monitoring efforts has been to assess the current ecological status and potential of the physical and vegetative components of riparian areas, and to further refine our understanding of the condition of riparian vegetation. Also, ecological status surveys are carried out to complement the land cover assessments that were used to develop the UKL TMDL (ODEQ, 2002).

Ecological status assessments are assessments that focus on evaluating the characteristics of soils, channels, vegetation and hydrology of riparian areas as they relate to expected ecological status potential. The definition of ecological status potential in this WQRP is consistent with the definition of system potential land cover used in the UKL TMDL (ODEQ 2002). System potential is the combination of potential near-stream or riparian land cover conditions and potential channel morphology conditions needed to fully support beneficial uses on 303(d) list streams and meet stream temperature standards by eliminating human-related stream temperature increases. System potential riparian land cover in the UKL TMDL is the land cover that could grow and reproduce along a stream that provides effective shade in amounts adequate to meet the stream temperature standard and eliminate human-related stream temperature increases. System or ecological status potential considers important variables such as soil conditions, climate, elevation, riparian vegetation characteristics, nutrient cycling, and surface and sub-surface hydrologic processes. When riparian vegetation land cover and channel widths are at system or ecological status potential human related stream temperature increases do not occur, and the stream fully supports designated beneficial uses. Thus, ecological assessments are important for providing information on current ecological status, and to identify locations where conditions could be improved.

Two types of methods are used to describe the ecological status of riparian areas and these are described in the following sections of this report.

2.9.1 Proper Functioning Condition Assessments

Proper Functioning Condition (PFC, BLM 1993) assessments are designed to characterize the interactions of vegetation, soils, biology, and hydrology in riparian areas. PFC is a way to quickly assess the ecological status and function of riparian areas. Assessing functionality and status of riparian areas involves determining riparian area potential and capability in terms of vegetative growth and channel condition. PFC conditions are sustainable, and represent mid- to late-seral vegetation conditions for most streams.

PFC assessments rely on the assumption that riparian areas have similarities in function, but also have unique attributes such as soils, vegetation, and flow regime. As a result, most areas need to be evaluated against their own capability and potential. Human influences can have significant impacts on riparian areas, and can change vegetation and channel capability and potential, sometimes irreversibly. Assessments, in order to be useful, need to consider these factors and the uniqueness of each system.

PFC assessments were done on pastures within grazing allotments (Table 10) in the UKB in 1997. Assessments were done on Key Areas where possible. Key Areas were selected to represent the most sensitive stream reach within a pasture, areas of historic high use, or areas representing overall condition and trend of riparian areas within the pasture. Key Areas are sites within a pasture within an allotment where resource damage or utilization levels are first reached. Monitoring Key Areas provides an indicator of whether the prescribed grazing management strategy is effective at maintaining allotment vegetative condition in satisfactory condition. Results show that 33 sites (70%) were determined to be at PFC, 2 sites were non-functional, 1 site was functional at risk with a downward trend, 4 sites were functional at risk with no apparent trend, and 7 sites were functional at risk with an upward trend.

Table 11. Proper Functioning Condition assessments for grazing allotments on FS lands in the UKB. Trends are listed for functional at risk ratings only.

Name	Functional Rating	Trend	Name	Functional Rating	Trend
Blue Creek	PFC		Sycan River	PFC	
SF Sprague River	PFC		Skull Creek	PFC	
Mineral Creek	PFC		Drainage Currier	PFC	
Whiskey John	PFC		NF Sprague River	PFC	
Whiskey John	PFC		Crazy Creek	PFC	
Deming Creek	PFC		Torrent Springs	PFC	
Deming Creek	PFC		Long Creek	PFC	
Fivemile Creek	PFC		Sycan River	PFC	
Buck Spring	PFC		Sycan River	PFC	
Big Meadow	PFC		Trib to Arkansas Res	NON	
Guard Station Spring	PFC		Pole Creek	NON	
Pole Creek	PFC		Mineral Creek	FAR	Upward
Dicks Well	PFC		Paradise Creek	FAR	Upward
Horseglade Spring	PFC		Lost Valley Creek	FAR	Upward
Fivemile Creek	PFC		Picket Flat	FAR	Upward
Swede Cabin Flat	PFC		NF Sprague River	FAR	Upward
Shepards Camp	PFC		Reservoir Creek	FAR	Upward
SF Sprague River	PFC		Deming Creek	FAR	Upward
Whiskey Creek	PFC		Swamp Creek	FAR	None
Tamarack Spring	PFC		Paradise Creek	FAR	None
Yellow Jacket Flat	PFC		Long Creek	FAR	None
NF Sprague River	PFC		Yaden Creek	FAR	None
NF Sprague River	PFC		Brownsworth Creek	FAR	Downward
Sycan River	PFC				

PFC- Proper functioning condition; NON- non-functional; FAR- functioning at risk

Proper functioning condition assessments provide a good starting point for assessing riparian conditions and functionality. The status of some riparian areas is difficult to discern, while others were relatively easy. Trend is reported for sites identified as functioning at risk, and sites with a downward trend are a high priority for changes in management. Functioning at risk sites with an upward trend are a priority for monitoring to determine continued upward trend. Non-functional areas represent areas where riparian values are severely compromised. Trends at sites that are at PFC can vary. Sites that are at PFC should maintain an upward trend in order to maintain high ecological status.

2.9.2 Potential Natural Communities

To monitor trends in riparian habitats and implement the Forest Plan, the Fremont and Winema National Forests began a riparian assessment survey in the mid-1990's. The goal of this survey was to determine the local ecological status of plant communities and their ecological gradients and fluvial settings. The survey includes direct measurement of vegetation, soil, and channel conditions, and classifies sites in early, mid, or late ecological status. Ecological status potential is measured through ecological status score cards, and is expressed as a percent of Potential Natural Communities (PNC). In assessing proper stream function, the National Riparian Service Team asserts proper function occurs in a mid ecological status (Prichard, 1998). A healthy mid status riparian area includes new gravel bars almost devoid of vegetation, older mid status bars with spotty willow and sedge growth, and older bars with silt accumulations and dense sedge or grass plant communities. Mid-status was likely historically the most common condition of properly functioning fluvial settings (Prichard, 1998). Assessment of trends in riparian areas, such as the rate of re-vegetation of gravel bars after flooding is important to consider. PNC evaluations are an assessment tool that provides information on ecological conditions that will be used to assess progress towards obtaining system potential identified in the UKL TMDL (ODEQ 2002).

Potential natural communities are the plant communities that would be established for a particular riparian area under present environmental conditions if all plant successional sequences were completed without additional natural or human-caused disturbances. Grazing by native fauna, natural disturbances such as drought, floods, wildfires, fire suppression, insects, and disease are inherent in the development of potential natural communities (Weixelman, 1999). Potential natural communities may include naturalized non-native plant species.

Kovalchik (1987) and Hopkins (1979) identified riparian communities and plant associations found in central and south central Oregon. These were used in combination with site-specific information to develop potential natural communities for the UKB. According to the Draft Interior Columbia Basin Ecosystem Management Project (ICBEMP, 1997), riparian vegetation objectives should be measured in terms of percent similarity of current riparian vegetation to the mature forest and or late ecological status potential range communities and condition.

The similarity of a site to the potential natural community can be evaluated using a method similar to Weixelman (1996). The specific soil, hydrologic, floristic, topographic, geographic, and functional features of a site are used to delineate similarity to PNC. The classification methodology involves the use of an ecological score card system that provides a standardized method for determining the current ecological status of different sites using features of both vegetation and environment. The score cards identify the range of high, moderate, or low similarity to PNC. For sites with a moderate similarity to PNC, an upward trend should be identified in riparian condition.

Table 12 shows monitoring data from a preliminary 1999 PNC survey of grazing Key Areas on the Sycan and Sprague River watersheds. Key Areas were established in grazing allotments to evaluate overall vegetative condition and to evaluate vegetative conditions along streams within allotment pastures. To monitor Key Areas, permanent vegetation plots and transects were established. Valley aspect, valley shape, valley width, percent slope of valley sides, valley bottom classification, landform type, ecosystem type, ecological condition, fluvial or geomorphic surface type, plant community, plant association, and seral stage are all determined at Key Area monitoring sites. The sites ranged from early to late-seral stage, and varied from 20-90% of PNC, with an average of 68% of PNC. Two of the sites were at early seral stage, 12 at mid seral, and 8 at late seral. Vegetation types included pine, sedge/grass, alder, and willow/shrub.

Table 12. Upper Klamath Basin Key Area ecological status, condition, and shade, Forest Service streams, Sprague and Sycan watersheds.

Key Area	Vegetation type	Existing Condition	Potential Status (% of PNC)	Effective Shade (%)
2	Willow/shrub	Mid-seral	75%	12%
3	Lodgepole pine	Mid-seral	80%	49%
4	Sedge/grass	Late seral	80%	32%
7	Sedge/grass	Mid-seral	75%	6%
10	Sedge/grass	Mid-seral	75%	10%
11	Ponderosa pine	Mid-seral	90%	31%
14	Alder	Late-seral	90%	89%
15A	Sedge/grass	Early-seral	20%	50%
15B	Willow/shrub	Early-seral	30%	50%
16	Sedge/grass	Late-seral	90%	41%
17	Sedge/grass	Mid-seral	20%	37%
PAI1	Willow/shrub	Late-seral	80%	4%
PAI2	Sedge/grass	Mid-seral	30%	3%
PAI3	Sedge/grass	Mid-seral	80%	16%
PAI4	Sedge/grass	Late-seral	85%	5%
PAI5	Sedge/grass	Mid-seral	65%	31%
PAI6	Sedge/grass	Mid-seral	60%	7%
PAI7	Willow/shrub	Late-seral	70%	29%
PAI8	Lodgepole pine	Late	90%	38%
PAI9	Sedge/grass	Mid-seral	50%	8%
PAI10	Sedge/grass	Mid-seral	65%	15%
SL1	Sedge/grass	Late	90%	14%

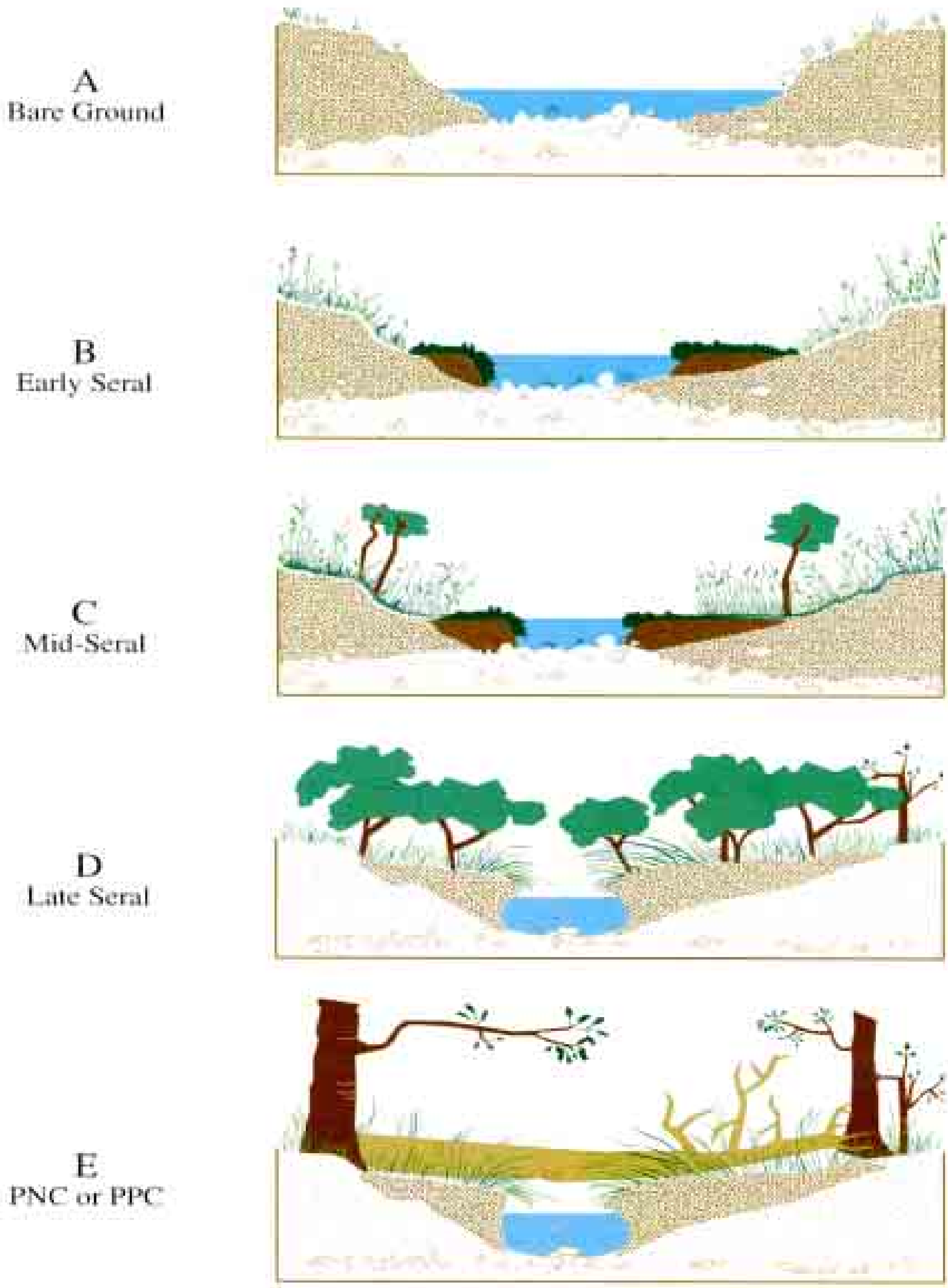

Figure 10. Cross-sections of hypothetical channel in alder riparian area showing channel and vegetation condition in relation to seral stages (BLM 1993).

3.0 Goals and Objectives

The goal of this Water Quality Restoration Plan (WQRP) is to summarize the specific actions and plans the Winema and Fremont National Forests and the BLM have taken and will take to protect and improve water quality in the UKB. It will also provide a plan for recovery of riparian systems and aquatic conditions in the UKB.

The goal for the FS and BLM is to meet water quality standards and protect beneficial uses by implementing appropriate management. These management practices, as presented in the Fremont and Winema National Forest Land and Resource Management Plans as amended by the Northwest Forest Plan (NWFP, USFS and BLM 1994) and the Inland Native Fish Strategy (INFISH, USFS 1995), will provide for recovery of the streams to the desired conditions as identified for the UKB under Oregon Administrative Rules (OAR) 340-41-962, "Klamath Basin Designated Beneficial Uses". Paramount to recovery is adherence to the Standards and Guidelines of the NWFP and INFISH that provide for effective riparian management. This includes designation and protection of riparian areas as buffers that provide important benefits for streams. The intent of the designation of riparian buffers is to recognize the importance of these areas from an ecological perspective, and provide appropriate measures to assure their protection. Recovery will also be enhanced by other plans including but not limited to active and passive restoration plans and programs, grazing management plans, and actions resulting from biological decisions for Endangered Species Act protection.

It is the intent of the FS and BLM to provide effective management that leads to recovery of riparian areas along streams and channel networks to the point where they provide shade in amounts commensurate with their land cover and stream channel potential as specified in the UKL TMDL. Additionally, the FS and BLM will address riparian and watershed processes that affect runoff generation, sediment production, and nutrient routing.

Riparian areas will be managed to provide shade in amounts adequate to attain the stream temperature water quality standard and to fully protect beneficial uses. Monitoring the ecological status of riparian areas will serve as an indicator of management effectiveness in attainment of water quality goals. Evaluation of PFC and PNC are tools that the FS will use to evaluate riparian conditions, and this information will be compared to targets for riparian land cover and stream channel morphology specified in the UKL TMDL (ODEQ 2002).

One of the management goals for riparian areas on FS land in the UKB is to attain a moderate to high similarity to PNC at monitoring sites in riparian areas throughout the UKB. PNC evaluations are an assessment tool that provide information on ecological conditions that will be used to assess progress towards obtaining system potential identified in the UKL TMDL (ODEQ 2002). Once sites are at moderate to high similarity to PNC, effective shade provided by the riparian canopy and channel conditions will be evaluated against effective shade targets outlined in the UKL TMDL (ODEQ 2002). For sites with a moderate similarity to PNC, an upward trend should be identified in riparian condition. For BLM lands in the Sprague River sub-basin, the management goal will be to meet the 5 Standards for Rangeland Health. These Standards are broad resource objectives dealing with ecological conditions and watershed function (BLM, 1997). The BLM administered lands near Bly will be assessed during the ten year period 1999-2008. Riparian and stream conditions in this area will compared against system potential shade and channel width targets specified in the UKL TMDL (ODEQ 2002).

All recovery goals and plans are strongly linked to maintaining those components of the ecosystem that are currently functioning, a strategy known as *protective management,* and improving those sites that show the greatest potential for improvement, known as *restorative management*. This land management strategy maximizes recovery while minimizing expensive, extensive, and risky restoration treatments.

3.1. General Water Quality Improvement Goals

The FS and BLM goals are to improve and protect water quality in streams on FS and BLM lands throughout the UKB. General water quality improvement goals for the UKB are:

I. Manage the areas within one to two site potential tree-heights on all streams to benefit the riparian areas including the aquatic habitat and conditions. For the UKB, the riparian protection buffers will be up to 320 feet on each side of the streams (INFISH and NWFP riparian management standards and guides). (protective)

II. Reduce stream temperatures on the 303(d) listed streams consistent with stream and riparian area ecological, land cover, and channel width system potential as specified in the UKL TMDL (ODEQ 2002), and to fully support beneficial uses and meet stream temperature standards. (protective and restorative)

III. Maintain the riparian areas across the UKB so that every stream whether listed or not is at its lowest potential temperature consistent with ecological status and system potential. (protective)

IV. Manage livestock grazing within allotments in riparian areas to ensure that channel and vegetation conditions are improving where needed as demonstrated through monitoring. (restorative)

V. Improve aquatic habitat in areas of severe degradation through treatments such as the placement of large wood in channels and recovery of riparian vegetation on unstable streambanks. Vegetation will recover by regrowth (passive restoration) and planting of riparian species along listed streams (restorative).

VI. Manage the National Forest and Bureau of Land Management road system to minimize sediment yield and runoff, and minimize delivery of sediment and runoff to streams (restorative).

VII. Manage BLM-administered wetlands near Agency Lake to maintain and restore wetland function, especially as it pertains to water quality, water yield, and wildlife habitat enhancement.

3.2 Water Quality Improvement Projects

In order to accomplish these goals, specific actions to improve water quality may consist of a variety of projects and activities. Projects are currently planned throughout the UKB. The general types of projects that are planned are listed in table 12. These projects are designed to reduce a variety of water quality impacts, especially those impacts from non-point sources. Some projects will be designed to directly address stream temperature reduction, such as riparian planting or in-channel restoration. Other projects will indirectly benefit stream temperature reduction by treating upland sediment sources or roads that may be having an impact on stream channel conditions. Some of these projects are currently being implemented, and others are planned.

Table 13. General water quality improvement projects planned or on-going on Forest Service and BLM lands in the UKB.

Potential Restoration Project	Description	Benefits	Proposed Schedule
Hydrologically disconnect roads	Improve conditions of roads near streams by improving road drainage effectiveness	Sediment and runoff reduction, improved channel and habitat conditions	On-going
Riparian vegetation planting	Re-establish riparian vegetation along degraded streams by planting riparian species.	Improved shade and channel conditions.	On-going
Riparian fencing	Build fences along riparian areas to manage livestock to accelerate recovery	Improved riparian vegetation and channel conditions	On-going
Spring protection	Protect springs by fencing or development of alternative water sources	Improved wetland habitat and late season flows	On-going
Meadow restoration	Remove encroaching pines and junipers from meadows	Improved meadow habitat and potential increases in low flows	On-going
Ditch and diversion improvements	Consistent with State water rights, improve diversion design and reduce impacts to channels and flows	Improved stream conditions for fish, lower stream temperatures, improved water accountability	Future
Timber stand improvements	Tend overstocked timber stands, reducing stand densities to resemble natural variability	Potential increased water yield and higher base flows	On-going

Table 13 (continued).

Channel restoration	Channel improvement including large wood additions, channel rehabilitation	Decreased stream temperatures, decreased channel widths, increased shade, improved fish habitat	On-going
Range allotment fences	Re-locate, construct or re-construct range fences to improve livestock management	Improved riparian and range condition	On-going
Upland Vegetation Treatments	Remove invasive juniper, plant native shrub species	Increased understory cover, reduced overland flow and erosion, improved riparian conditions	On-going
Wetland Restoration	Manipulate water levels to restore wetland function, plant native vegetation, restore adjacent stream channels	Reduced nutrient loading, improved fish and wildlife habitat	On-going
Monitoring	Evaluate projects and water quality improvement	Provide information on level of water quality improvement	On-going

3.3. Goals for Stream Shading

It is the intent of the FS to provide effective management that leads to recovery of riparian areas along streams and channel networks to the point where they provide effective shade and maintain lower stream temperatures in amounts commensurate with their ecological, land cover and stream morphology potential as specified in the UKL TMDL. Additionally, the FS and BLM will address riparian and watershed processes that affect runoff generation, sediment production, and nutrient routing.

Riparian areas will be managed to provide effective shade in amounts adequate to attain stream temperature water quality standards and to fully protect beneficial uses. Monitoring the ecological status of riparian areas will serve as an indicator of management effectiveness in attainment of water quality goals. Evaluation of PNC is one tool that the FS will use to evaluate riparian conditions. One of the management goals for riparian areas on FS land in the UKB is to attain a moderate to high similarity to PNC at monitoring sites in riparian areas throughout the UKB. For sites with a moderate similarity to PNC, an upward trend should be identified in riparian condition. As part of PNC evaluations, once sites are at moderate to high similarity to PNC, effective shade provided by the riparian canopy and channel conditions will be evaluated against effective shade targets outlined in the UKL TMDL (ODEQ 2002). For BLM lands in the Sprague River sub-basin, the management goal will be to meet the 5 Standards for Rangeland Health. These

Standards are broad resource objectives dealing with ecological conditions and watershed function (BLM, 1997). The BLM administered lands near Bly will be assessed during the ten year period 1999-2008. Periodically riparian conditions will be evaluated and compared to targets for effective shade specified in the UKL TMDL.

The overall goal of this WQRP is to show how progress will be made to achieve compliance with water quality standards for temperature for each 303(d) listed stream. This WQRP describes a strategy for reducing pollutant discharges from nonpoint sources to the load allocation targets described in the TMDL. In the TMDL, effective shade is a “surrogate measure” for solar radiant heat energy delivered to streams. The role of effective shade in the TMDL and in this WQRP is to serve as an indicator of solar loading reductions.

3.3.1 Potential Shade for Forest Service Streams

Loading capacities for incoming solar radiation along streams can be used to define a target for effective shade for different vegetation types. To address information needs required for the Upper Klamath Lake TMDL and to provide preliminary target shade values for shade on streams, monitoring of vegetation and shade conditions along streams considered at their ecological status potential was completed on FS lands in the UKB in 1999. McNamara et. al. (2000) summarizes these results. For the purposes of this monitoring, riparian vegetation types were simplified into 7 major community groups. These groups represent the potential shade producing capabilities of vegetation types common to the UKB. These community groups were monitored to help understand the relationships between vegetation, stream channel conditions, and stream shade. Within each of the 7 vegetation groups, stream reaches were selected for measurement where the riparian vegetation was considered to be at site potential.

Sites evaluated in 1999 had generally been excluded from livestock grazing for at least four years. Past timber harvest may have occurred at some of these locations, but impacts were not recent. Effective shade values from 1999 surveys at potential sites provide an estimate of potential values for shade for riparian areas on Forest Service lands. Table 13 shows the range of shade data values sampled within each vegetation group, and Table 14 further stratifies the data by stream width within each vegetation type.

Table 14. Shade potential for seven plant community groups. Site average percent shade, maximum and minimum values, sample standard deviation, and number of samples for potential reaches for each riparian community group are shown, 1999 survey. These sites are at moderate to high similarity to PNC.

	Sedge Grass	Willow/ Shrub	Alder	Ctnwood Aspen	Lodgepole Pine	Pond. Pine	White Fir
Avg.% shade (n)	20(15)	30(12)	60(8)	56(14)	49(13)	54(10)	82(13)
Min	6	4	28	22	22	39	64
Max	56	68	88	94	69	80	92
SD	16	21	22	26	15	12	9

Table 15. Shade potential average percent shade by stream wetted width for each riparian community group, 1999 survey. From 1 to 12 shade measurements were taken at potential sites within each width category. 1999 survey.

Stream Wetted Width(ft)	Sedge Grass % Shade	Willow/ Shrub % Shade	Alder % Shade	Ctnwood Aspen % Shade	Lodgepole Pine % Shade	Pond. Pine % Shade	White Fir % Shade
0-5	36	45	77	81	66	69	86
5-15	37	28	82	60	54	52	81
15+	14	23	40	28	38	47	67

At present, these values represent our best estimate of shade that can be produced when conditions along streams are at their system or ecological status potential. Efforts are on-going to provide additional surveys and information on ecological status of riparian areas, and to compare ecological status evaluations with land cover and stream width goals in the UKL TMDL (ODEQ 2002). Further, as these surveys are completed, this information will be used to refine the definition of ecological status potential in riparian areas.

3.3.2 TMDL Target Shade Values

The Upper Klamath Lake TMDL (ODEQ 2002) has determined target effective shade values for the North and South Forks of the Sprague Rivers, the Sycan River, Fishhole and Trout Creeks, and the Williamson River. Where specific effective shade values are not determined, appropriate effective shade values have been determined for different land cover types. The TMDL defines effective shade as the percent reduction in potential solar load delivered to the water surface. Solar heat load is the pollutant that is directly responsible for increased stream temperatures. The role of effective shade in the TMDL is to reduce heating by solar radiation, and to serve as an indicator or surrogate for solar loading capacities. Stream temperatures above the ODEQ temperature standard occur as a result of increased heat loading from solar radiation due to reduction of stream shade and other factors such as reduction in streamflow. The intent of the FS is to meet these standards.

Because many factors interact to influence stream temperature, the surrogate measure (percent effective shade) relies on restoring and protecting riparian vegetation to increase surface shade levels along streams, improving channel conditions and stability, and reducing the area of the stream exposed to radiant processes. Effective shade screens the water surface from the direct rays of the sun. Highly shaded streams often experience less heating due to reduced input of solar energy. Site specific effective shade surrogates were developed to help determine the nonpoint source solar radiation heat loading allocations in the TMDL. Attainment of the effective shade surrogate measures for streams is equivalent to attainment of the nonpoint source solar heat loading allocations.

The TMDL for the Upper Klamath Lake Drainage also identified effective shade that would be expected under five different types of near-stream vegetation. These were formulated to address effective shade targets for streams where site-specific effective shade simulations were not completed, and show effective shade and solar load as a function of channel width and stream aspect. The near-stream vegetation types that were analyzed for the shade curves were large conifer, large hardwood, large conifer/hardwood mix, wetland shrub, and graminoid/forb. For a given stream and riparian area, the FS will adjust management activities to meet these shade curve targets.

3.3.3 Target Stream Channel Conditions

Channel width is a fundamental factor in determining a streams solar heating potential and ultimately its thermal regime. Many other factors that can influence stream heating are directly influenced by channel width. Thus, channel features such as width or width to depth ratio can be used as surrogates for assessment of effective shade along streams. Using stream geomorphic regional curves developed by the FS (Bakke et. al. 2000), target width to depth ratios were developed by ODEQ (2002) for UKB streams by Rosgen stream type (Rosgen 1996). These were done so that target stream widths could be established for different Rosgen level 1 stream types, and to use channel condition as a surrogate for estimating solar loading for the Upper Klamath Lake TMDL. The FS intends to meet these target values for channel widths on lands they manage in the UKB.

ODEQ (2002) identified target Rosgen stream types and channel width targets for mainstem and tributary streams in the UKB. A, B, C, and E type channels were considered to be in a more stable condition with little potential for evolution to another stream type (assuming that current climate and land use conditions do not change substantially). D type channels are braided as a result of either natural or human-caused disturbance. Generally, F channel types for UKB streams were considered to be below width to depth potential, and that through channel adjustment and active or passive restoration, would eventually adjust to C or E channels, depending on drainage area. Management goals for FS streams include focusing channel restoration work and provide management measures to improve channel conditions on 303(d) list streams. ODEQ target stream width curves will be used to verify effectiveness of management and restoration of channels.

Table 16. Current Rosgen stream types and TMDL target or surrogate stream channel types and width to depth ratios (ODEQ 2002).

<table>
<tr><th>Current Level 1 Rosgen Stream Type</th><th colspan="6">Potential Level 1 Rosgen Stream Type and Targeted Width to Depth Ratio</th></tr>
<tr><td>A</td><td colspan="6">A; W:D = 7.9</td></tr>
<tr><td>B</td><td colspan="6">B; W:D = 18.6</td></tr>
<tr><td>C</td><td colspan="3">C; W:D = 29.8</td><td colspan="3">E; W:D = 7.1</td></tr>
<tr><td>D</td><td colspan="2">C; W:D=29.8</td><td colspan="2">D; W:D=N/A</td><td colspan="2">E; W:D = 7.1</td></tr>
<tr><td>E</td><td colspan="6">E; W:D= 7.1</td></tr>
<tr><td>F</td><td colspan="3">C; W:D = 29.8</td><td colspan="3">E; W:D = 7.1</td></tr>
<tr><td>G</td><td colspan="3">C; W:D + 29.8</td><td colspan="3">E; W:D = 7.1</td></tr>
</table>

4.0 Proposed Management Measures

A variety of management measures will be used to improve water quality and meet the load allocations specified for streams in the Upper Klamath Lake Drainage TMDL (ODEQ 2002). Management measures designed to reduce stream temperatures include applying standards and guides for stream protection, application of Best Management Practices, terms and conditions of U.S. Fish and Wildlife Service (USFWS) biological opinions, grazing allotment management plans, and other plans, policies, and procedures.

4.1. Northwest Forest Plan and Inland Native Fish Strategy

Since 1990, the NWFP and INFISH have amended certain parts of the Fremont and Winema Forest Land and Resource Management Plans that affect riparian and aquatic resources. Under the NWFP Aquatic Conservation Strategy and INFISH, riparian stream buffers have been established on FS lands throughout the Pacific Northwest. Streamside buffers are areas along streams where special standards and guidelines direct land use. The intent is to recognize the importance of these areas from an ecological perspective, and provide appropriate measures to assure their protection. The riparian reserve widths for streams in the UKB are believed to be adequate to maintain values of these areas for providing stream shading, input of woody debris to the stream, and other important functions of riparian areas that affect stream habitat, temperature, and biota. The widths of streamside buffers were initially set by standards and guides in the NWFP and INFISH. However, the intent of these plans was that these widths would be determined through site specific watershed analysis of ecologic and geomorphic variables, where the level of riparian protection for a watershed is fine-tuned.

As is specified in the Aquatic Conservation Strategy (ACS) of the Northwest Forest Plan, and in the Inland Native Fish Strategy (INFISH) both sides of all intermittent and perennial streams on FS land in the UKB will be buffered. These buffers are areas along streams where riparian dependent resources receive primary emphasis. The NWFP Aquatic Conservation Strategy terms these buffers Riparian Reserves, while they are Riparian Habitat Conservation Areas under INFISH. These widths are considered interim, and may be modified following completion of watershed or project area analysis. The interim widths of these buffers are nearly identical between the two plans. The widths of these buffers are determined from ACS and INFISH guidelines. The buffer width for the fish-bearing streams in the Upper Klamath River Basin is 300 feet or two site potential tree heights on each side of the stream. For non-fish-bearing streams the streamside buffers are 150 feet on each side or one site potential tree height. Buffers have also been established for intermittent streams. As a result, a large amount of acreage is managed as streamside buffers on the Winema and Fremont National Forests.

4.2 Standards and Guidelines

Standards and guides specified in the Fremont and Winema Land and Resource Management Plans (as amended) will be used to help meet the goals of the Clean Water Act on FS lands in the UKB. In addition, the following Northwest Forest Plan standards and guidelines from the NWFP Record of Decision (USFS 1994) will be used to help meet the goals of the UKB Water Quality Restoration Plan.

- Stream Temperature – Increased Shade
  - Aquatic Conservation Strategy: B9 – B11, C30
  - Riparian Vegetation: B31
  - Riparian Reserves: B12 to B17, C30 – C38, ROD 9
  - Watershed Restoration: B30
- Stream Temperature – Channel Form
  - Aquatic Conservation Strategy: B9 – B11, C30
  - Riparian Vegetation: B31
  - Riparian Reserves: B12 to B17, C30 – C38, ROD 9
  - Watershed Restoration: B30
  - Roads: B19, B31 to B33
- Habitat Modification
  - Aquatic Conservation Strategy: B9 – B11, C30
  - Riparian Vegetation: B31
  - Riparian Reserves: B12 to B17, C30 – C38, ROD 9
  - Watershed Restoration: B30
  - Roads: B19, B31 to B33
  - Instream Habitat Structures: B31

The following INFISH standards and guidelines from the Inland Native Fish Strategy Environmental Assessment (USFS 1995) are to be used.

- Stream Temperature – Increased shade
  - Riparian Goals and Management Objectives: E2 - E4
  - Riparian Habitat Conservation Areas: E5 – E6
  - Watershed and Habitat Restoration: E13
  - Fisheries and Wildlife Restoration: E13
- Stream Temperature- Channel Form
  - Riparian Goals and Management Objectives: E2 - E4
  - Riparian Habitat Conservation Areas: E5 – E6
  - Roads: E7
- Habitat Modification
  - Riparian Habitat Conservation Areas: E5 – E6
  - Riparian Goals and Management Objectives: E2 - E4
  - Watershed and Habitat Restoration: E13
  - Timber Management: E7
  - Roads Management: E7
  - Grazing Management: E9

4.3 Wetland Restoration

The Wood River and Fourmile parcels encompass about 4,100 acres of wetlands. Since 1995, extensive restoration has occurred in the Wood River Wetland:

Phase 1 (completed in 1997): Retrofitting of water management infrastructure, in partnership with Ducks Unlimited and USFWS.

Phase 2 (completed in 1998): Installation of water control structures.

Phase 3 (completed in 2001): Restoration of form and hydrologic function of the lower Wood River (including the Wood River delta), in partnership with Oregon Trout and the USFWS.

Phase 4 (proposed): Develop a more sinuous and diverse interface along Sevenmile Canal. This would involve a two mile reach of existing levee. Studies are underway to examine the feasibility of this portion of the project.

In addition to reducing nutrient loading into Agency Lake, this restoration project has reduced the warming rate of water in the Wood River and has improved fish and wildlife habitat (BLM 1999; BLM 2000). Future wetland management may include more intense management of water levels than occurs at present, in order to increase the nutrient filtering role of the wetlands. In general, the wetland restoration objectives and project work performed since BLM administration began is not compatible with livestock grazing, and none is expected to be authorized in the future.

Wetland restoration at the Wood River and Fourmile parcels has demonstrated that current wetland management has been successful in reducing nonpoint sources of phosphorous. Reduction in phosphorous loads is consistent with nonpoint phosphorous load reductions specified in the UKL TMDL (ODEQ 2002). Using the estimates provided in Table 10, BLM management of the Wood River Wetland has reduced phosphorous loading to the Wood River by about 550 kg/year and to Sevenmile Creek by about 480 kg/year. This account for about 1.5% and 3% of annual phosphorous loading to Wood River and Sevenmile Creek, respectively. Opportunities for improving wetland management as a tool in reducing non-point sources will continue to be explored

Currently, the Fourmile parcel is a proposed Area of Critical Environmental Concern (ACEC) for which the planning work is still pending. No livestock grazing is currently allowed or is expected to be authorized in the future under this special designation. Since grazing has stopped, vegetation establishment along channel margins has led to reductions in channel width. Potential restoration projects for this parcel have been identified. If implemented, these would focus on restoring riparian/wetland vegetation communities affected by past grazing, reducing channel width-to-depth ratios in Fourmile Creek, improving fish passage, and restoring the connection between the wetland, Fourmile Creek, and Threemile Creek.

4.4 Margin of Safety

The Clean Water Act (CWA) requires that each TMDL be established with a margin of safety. A Margin of Safety is a way to estimate how numeric targets for a pollutant compare to the level of water quality protection. For instance, for management of shade producing vegetation in the riparian areas, it is apparent from research that the most effective zone for shade producing vegetation along streams is within 100 feet of streams (FEMAT, 1993). The 150 foot minimum width of riparian buffers on the Winema and Fremont Forests is established by mandatory standards and guidelines. Thus, there is an adequate margin of safety within the streamside buffers to provide for maintenance of stream temperatures.

Numerical models used to develop the stream temperature TMDL have uncertainties inherent in estimating the complex response of streams to changes in management designed to reduce stream temperature. Factors such as how much data is available, and how well stream heating processes are understood have a bearing on the accuracy of these models. This is another reason why a factor of safety is incorporated into TMDLs and WQRPs.

Stream shade can be significantly affected by the effects of livestock grazing. Grazing is managed under a set of specific standards designed to ensure improving riparian and channel conditions. Grazing effects will be monitored annually at Key Areas and evaluated to determine the potential natural community and the current ecological status of the site. Sites will be managed to attain a moderate to high similarity to PNC. Conditions will be evaluated to determine compliance with targets for effective shade specified in the UKL TMDL (ODEQ 2002), and for compliance with system potential for riparian and stream channel conditions. Through effective grazing management, and demonstration through monitoring of an upward trend in conditions and in improving riparian and channel conditions along streams, an adequate Margin of Safety for maintenance of effective shade should be maintained.

4.5 Best Management Practices

BMP's are designed to control sources of non-point source pollution such as sediment from forest practices. The application of BMP's to forest management activities is mandatory. BMP's are selected based on site-specific characteristics, and must be monitored to see if they were implemented and for their effectiveness at controlling non-point source pollution. The Winema and Fremont Land and Resource Management Plans state that:

> "The forest shall comply with State requirements in accordance with the Clean Water Act for protecting waters of the State of Oregon through planning, applying, and monitoring Best Management Practices (BMP's) consistent with the Clean Water Act, regulations and federal guidance."

Numerous BMPs that address water quality are included within Appendix D of the KFRA RMP (1995). These address riparian reserves, road management, grazing, timber harvest, and other management actions that can affect water quality.

Specific BMP's that affect a wide range of forest management on FS lands are published in General Water Quality Best Management Practices (U.S. Forest Service Pacific Northwest Region, 1988). These BMP's can be changed to reflect site-specific conditions so that their effectiveness can be optimized.

5.0 Timeline for Implementation

The major provisions of this plan have already been implemented. Land and Resource Management plans for FS lands that have provided for riparian habitat and water quality improvement have been implemented for over a decade. The KFRA RMP was finalized in 1995. When the Northwest Forest Plan was implemented in 1994, and INFISH was implemented in 1995, additional areas along all streams, not just perennial, were set aside in streamside buffers dedicated to improving aquatic and riparian area habitat and water quality. Guidance provided by these two plans and other plans including Endangered Species Act Biological Opinions (U.S. Fish and Wildlife Service, 1997) governs riparian area management on the National Forest System and BLM lands within the UKB.

Specific activities designed to improve conditions on the ground will require analysis under the National Environmental Policy Act. The timing for implementation of those activities is dependent on funding levels.

It may take some period of time, from several years to several decades after full implementation of this WQRP before management practices become effective in reducing and controlling stream heating due to lack of riparian vegetation. Stream temperature and habitat modification recovery is largely dependent on vegetation and channel recovery. Actions implemented now will slowly begin to show returns in terms of reduced stream temperatures or improved aquatic habitat. Full recovery of these conditions may not occur in some systems for many decades. Other streams will begin to recover more quickly. Stream temperatures will begin to decline and will recover before the riparian areas reach their maximum potentials.

6.0 Identification of Responsible Participants

This plan was produced as a joint activity by the Oregon Department of Environmental Quality and the FS. Additional input was provided by the Bureau of Land Management. As the managers of the land where the listed streams are located, the FS and BLM will implement the actions identified in the plan and will be responsible for improved conditions. The Forest Supervisor of the Winema and Fremont National Forests is the official responsible for implementation of this plan on the National Forests. The Field Manager for the Klamath Falls Resource Area is the official responsible for implementation of this plan on land administered by the BLM.

Private landowners are not required to follow the specific provisions contained in this plan. However, all federal land managers are subject to the requirements of the Northwest Forest Plan and INFISH (in the areas where those plans apply). The National Park Service can be expected to implement the basic tenets contained here in the management of the streamside buffers on their land.

7.0 Reasonable Assurance of Implementation

The FS is committed under the terms of the Northwest Forest Plan, INFISH and the Winema and Fremont National Forest Land and Resource Management Plans (as amended) to provide management of the aquatic resources in a manner that will produce water of acceptable quality. The KFRA RMP (and its discussion of applying the Aquatic Conservation Strategy to all lands within the KFRA) commits the BLM to maintaining and restoring water quality. An annual monitoring report documenting accomplishments in these areas will be produced. If monitoring indicates that sufficient progress toward the goals contained in this plan are not being made, the goals and activities will be revisited and changes made as necessary to management to assure attainment of water quality standards.

8.0 Monitoring and Evaluation

8.1 Implementation Monitoring – Riparian Vegetation Condition

This Water Quality Restoration Plan will serve as a guidance document, in addition to the Northwest Forest Plan, the Winema and Fremont National Forest Land and Resource Management Plans, and INFISH to provide direction to FS personnel engaged in project planning. This will insure that the recommendations for riparian improvements and management are given full consideration at every opportunity.

To insure implementation of this plan, the National Forests will require timber sale administrators (TSOs) to certify that harvest operations have maintained the prescribed streamside buffers. Further, livestock grazing programs will be monitored for compliance with all applicable standards contained in the Forest Plans and USFWS Biological Opinions. This type of implementation monitoring will occur annually.

The BLM conducts annual implementation monitoring of BMPs for timber sales and other management actions (published in the Annual Program Summary). Periodic monitoring of grazing use and utilization occurs to ensure that proper grazing use is occurring, grazing lease parameters are being followed, and that LUP and other resource objectives are being met.

8.2 Implementation Monitoring - Stream Channel Condition and Wetland Restoration

Restoration actions designed to improve stream channel and riparian conditions will be reported as part of the Forest-wide annual monitoring report. Stream channel conditions will be compared to target channel width to depth ratios prescribed in the TMDL.

The BLM and the U.S. Geological Survey are engaged in a cooperative monitoring effort that will provide guidance on adaptive management of the Wood River Wetland. The effort is focused on the question of how to best optimize water quality, water quantity, and wildlife habitat. The monitoring effort commenced in 2003 and is being coordinated with ODEQ, as well as other agencies with wetland management responsibilities.

The BLM publishes an annual report describing the implementation of restoration projects at the Wood River Wetland.

8.3 Effectiveness Monitoring – Riparian Vegetation Condition

Guidelines in the Northwest Forest Plan, INFISH and Endangered Species Act Biological Opinions (U.S. Fish and Wildlife Service, 1997) on livestock grazing specify that vegetation management activities that occur within the streamside buffers must have a goal of improving riparian conditions. Riparian ecological conditions will be assessed using score cards that will help determine ecological status of riparian areas. These assessments will be done at five to ten year intervals at select representative monitoring locations or stream reaches to determine trends in riparian ecological status. Periodically riparian conditions will be evaluated and compared to targets for effective shade specified in the UKL TMDL (ODEQ 2002). Riparian areas will be managed to provide effective shade in amounts adequate to attain stream temperature water quality standards and to fully protect beneficial uses. Monitoring the ecological status of riparian areas will serve as an indicator of management effectiveness in attainment of water quality goals. Evaluation of PNC is the primary method that the FS will use to evaluate riparian conditions. One of the management goals for riparian areas on FS land in the UKB is to attain a moderate to high similarity to PNC at monitoring sites in riparian areas throughout the UKB. PNC evaluations are an assessment tool that provides information on ecological conditions that will be used to assess progress towards obtaining system potential identified in the UKL TMDL (ODEQ 2002). Once sites are at moderate to high similarity to PNC, effective shade provided by the riparian canopy and channel conditions will be evaluated against effective shade targets outlined in the UKL TMDL (ODEQ 2002). For sites with a moderate similarity to PNC, an upward trend should be identified in riparian condition. For BLM lands in the Sprague River sub-basin, the management goal will be to meet the 5 Standards for Rangeland Health. These Standards are broad resource objectives dealing with water quality, ecological conditions and watershed function (BLM, 1997). The BLM administered lands near Bly will be assessed during the ten year period 1999-2008.

8.4 Effectiveness Monitoring - Stream Channel Condition and Wetland Restoration

Stream channels will be monitored through Region 6 level II stream inventories to determine Rosgen Level 1 stream types. Level 1 Rosgen stream types, stream channel stability and habitat conditions, and average width to depth ratios of stream reaches will be monitored through repeated level II assessments at approximately 5 and 10 year intervals (USDA, 1999). Surveys will be compared to TMDL target stream types and width to depth ratios. Forest or contract personnel will complete this monitoring. Results will be included in the annual Forest Monitoring Report, which is available from the Supervisor's Office of the Winema and Fremont National Forests.

The BLM publishes an annual report describing the effects of restoration projects on water quality in and near the Wood River Wetland.

8.5 Effectiveness Monitoring - Stream Temperature

The Winema and Fremont National Forests and the KFRA will continue annual monitoring of water temperature throughout the UKB. Data collection methods and equipment will follow ODEQ protocols. At a minimum monitoring will continue on all 303(d) listed streams until such time as they reach the state standard. Generally, stream temperatures will be monitored from June 1 to September 30 to insure that critical high temperature periods are covered. Measurements will be made with sensors programmed to record hourly samples. Qualified personnel will review raw data and erroneous data due to unit malfunction or other factors will be deleted. Valid data will be processed to compute the 7-day moving average of daily maximum temperature at each site. The resulting files will be stored in the agency computer system. A summary of the data will be forwarded annually to the Oregon Department of Environmental Quality.

After the 10th year, the Forest will analyze the stream temperature data that has been collected against the types of activities that have occurred in the watershed and make recommendations as to management effectiveness. At that time, the Forest will reevaluate this plan and submit any proposed revisions, as well as the results of the data collection and analysis to ODEQ for consideration and concurrence.

Discussion of the results of all monitoring associated with compliance with this plan will be published annually in the Forest Monitoring Report.

9.0 Public Involvement

Many of the elements that are contained in this plan are derived from existing land use planning documents such as the Winema and Fremont National Forest LRMP's, the KFRA RMP, the Upper Klamath Basin and Wood River Wetland RMP/EIS, and the Record of Decision for Amendments to Forest Service and Bureau of Land Management Planning Documents Within the Range of the Northern Spotted Owl (ROD). These documents received broad based public comment during scoping prior to development of alternatives and during public appeal of both documents. Both documents also received numerous responses to the Draft Environmental Impact Statement that was published for review, prior to development of the Final Environmental Impact Statement and Record of Decision.

The Oregon Department of Environmental Quality has lead responsibility for creating TMDLs and Water Quality Management Plans (WQMPs) to address water quality impaired streams in Oregon. This Water Quality Restoration Plan will be provided to DEQ for incorporation into an overall WQMP for the Upper Klamath River Basin. DEQ has a comprehensive public involvement strategy, which includes informational sessions, mailings, and public hearings. The FS and BLM will provide support and participate in this public outreach.

10.0 Maintenance of Effort over Time

Efforts to improve water quality on FS and BLM lands are on-going and will continue. Uncertainties regarding funding for restoration and monitoring of riparian areas and streams will influence the level of activity that takes place year to year. However, the FS and BLM are committed to implementing strategies for improving water quality and monitoring stream and riparian conditions. The amount of watershed restoration that takes place each year will vary depending on levels of funding, but efforts will be made to sustain some level of watershed restoration.

Water temperature, stream channel condition surveys, and riparian ecological assessment monitoring by FS personnel in the UKB have been a regular part of the FS's watershed program in recent years. The FS and BLM are committed to maintenance of these monitoring efforts. Funds are annually designated specifically for water temperature monitoring and stream surveys.

11.0 Discussion of Costs and Funding

Implementation of all aspects of this plan involves the collective efforts of personnel from several departments and funding from several programs within the FS's and BLM's total operations. Money for ongoing support of the plan is not likely to be allocated as a separate budget item but will continue to be multi-financed from many sources. It is important to note that many of the specific management practices contained in the plan represent mitigation of existing management activities such as timber harvest, livestock grazing, fuels management, etc. These practices are not dependent on funds allocated for soil and water improvement.

With the exception of the direct stream temperature monitoring and the stream surveys, most elements of this plan will be implemented through special emphasis within other programs such as vegetation management and monitoring, monitoring compliance with grazing standards, and regularly scheduled stream surveys. These activities have funding sources that are not tied to the Water Quality Restoration Plan.

Actions specifically necessary to implement the plan include the field monitoring of ecological status, stream inventories, stream temperature, the processing and storage of computer databases, and the writing of management plans and monitoring reports. The cost of these activities is estimated to be between $30,000 and $50,000 per year.

The Winema and Fremont National Forests receive an annual budget allocation specifically for soil and water improvements and operations. While it is not possible to discuss outyear budgeting with any degree of assurance, the amount in recent years has varied. This money is available, in addition to funding for the Forest's programs discussed above, to pay for projects aimed at improving water quality or other watershed conditions.

In addition to the cost of property acquisition, the BLM and partners have spent over $3 million to restore the Wood River Wetland. Future funding for water quality restoration and monitoring projects will be derived from base funding, cost shares and matches, competitive funding from the state office, the USFWS Ecosystem Restoration Office, and grants or partnerships through other programs.

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